# Report to the Environmental Review Commission on the Status of Water Quality in Water Supply Reservoirs Sampled by the Division of Water Quality

April 2006

North Carolina
Environmental Management Commission

# EXECUTIVE SUMMARY

## Background

Under Section 2(a) of the 2005 Drinking Water Reservoir Protection Act (SB981), the Environmental Management Commission (EMC) is charged with analyzing existing water quality data for water supply reservoirs sampled by the Division of Water Quality (DWQ) and reporting its findings and recommendations to the Environmental Review Commission by May 1, 2006.

Data review was confined to January 1995 through May 2005 to provide the most recent assessment. Of the 160 lakes that DWQ monitors, data from the 95 reservoirs classified as water supplies and sampled during this time period were reviewed. These lakes are from 10 river basins and are located in the piedmont and mountain regions of North Carolina.

As the Act focused on elevated nutrients in water supplies, this analysis includes those standards regularly sampled by DWQ related to nutrient enrichment (also referred to as eutrophication): chlorophyll a, dissolved oxygen, pH and turbidity. In some cases, the discussions of individual lakes include discussions of water quality problems associated with parameters that have no standards such as aquatic weeds.

## Findings:

- Fourteen percent of the water supply reservoirs (13 out of 95) sampled by DWQ during January 1995 through May 2005 did not meet all eutrophication related standards based on available data.
- Those lakes that did not meet all of the eutrophication-related standards are: Graham-Mebane Reservoir, High Point Lake, Jordan Lake, Stoney Creek Reservoir, Lake Mackintosh, Pittsboro Lake, Lake Rhodhiss, Cedar Cliff Lake, Lake Sequoyah, Falls of the Neuse Reservoir, High Rock Lake, Lake Lee, and Lake Twitty.
- Graham-Mebane, High Point, Jordan, Mackintosh, Pittsboro, Stoney Creek, Rhodhiss, Falls of the Neuse, and High Rock have strategies in place or under development to address their water quality concerns.
- Additional sampling is planned for Lakes Lee and Twitty.
- Six lakes had water quality problems (taste, odor, color) sufficient to require additional treatment either in-lake or at the treatment facility: High Point, Oak Hollow, Lucas, Twitty, Hickory and Rhodhiss.
- In addition to nutrients, aquatic weeds and sediment are problems in water supplies. Fourteen lakes, mainly in the Cape Fear and Catawba River basins, are currently infested with aquatic weeds at levels that require some treatment.

## Recommendations

There was not sufficient data from DWQ's sampling program to determine with confidence if many of these reservoirs were meeting or not meeting surface water quality standards. The current ambient monitoring program is designed to provide snapshots of water quality during the period of the year when the effects of eutrophication are most noticeable. DWQ prioritizes additional monitoring based on the ambient lakes monitoring. The current monitoring program resources are insufficient to perform large-scale assessments of eutrophication in multiple reservoirs where additional monitoring has not been prioritized. Such evaluations are possible; however, a significant input of staff, equipment and laboratory support would be required to perform these evaluations on all water supply reservoirs.

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# Section 1. Introduction and Program Overview

## 1.1. Introduction

Lakes and reservoirs are integral features of the North Carolina landscape, supplying water for personal, industrial and municipal users. Lakes provide recreational opportunities and aesthetic enjoyment for the public, and support rich communities of aquatic plants and animals. Public use of the state's lakes is high, and lake-related recreation provides significant revenues. The North Carolina Environmental Management Commission and Division of Water Quality are committed to protecting these valuable resources for public use.

Recognizing the importance of North Carolina's waters, the Legislature adopted the 2005 Drinking Water Reservoir Protection Act (SB981). Under Section 2(a) of this Act, the Environmental Management Commission is charged with studying the state's drinking water reservoirs, determining which reservoirs are not meeting surface water quality standards using available data, and reporting their findings and recommendations to the Environmental Review Commission.

This report was prepared to meet that requirement and to provide some additional information on the Division of Water Quality's (DWQ) Ambient Lakes Monitoring Program. An overview of the Ambient Lakes Monitoring Program (ALMP) is presented as well as an explanation of water supply classifications, standards and rules. Other programs that assist with protection of water supplies are discussed briefly. Following those sections there is a review of the data collected over the past 24 years, basin by basin discussion of lakes with exceedances of the standards and recommendations.

## 1.2. Division of Water Quality Ambient Lakes Monitoring Program

Assessment of water quality is necessary to determine the health of a reservoir and its suitability for public use. Reservoirs in North Carolina have been monitored for several decades; however, current electronic data only goes back to 1981 when the DWQ received federal Clean Water Act funding to classify the trophic (or nutrient enrichment) status of North Carolina's publicly owned freshwater lakes/reservoirs[1], and to prioritize them for restoration. This report looks at the most recent ten years of data as it provides a better picture of current conditions in the reservoirs.

EPA has continued to provide limited funding for monitoring lakes under Section 314 and recently 319 of the Federal Clean Water Act. The emphasis continues to be on eutrophication, where eutrophication is defined as human-induced increases in nutrient loading above natural levels in a lake. This has driven DWQ's program

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[1] The terms lake and reservoir are used interchangeably throughout this report. Technically, lake refers to a natural waterbody. North Carolina has only a few natural lakes in the sandhills and coastal plain. All other "lakes" are reservoirs created by man.

to focus its monitoring toward the summer months when eutrophication impacts are most prevalent.

A total of 160 publicly owned lakes have been sampled as part of the ALMP. Those lakes are sampled once every five years per the DWQ's Basinwide Assessment Program's schedule. Data are used to prioritize lakes for restoration efforts and, starting in 2004, resources are being reorganized to provide sufficient data to determine if water quality standards are being met and to support special studies and development of lake total maximum daily loads (TMDL). A TMDL is a calculation of the maximum amount of a pollutant that a water body can receive and still meet water quality standards and it includes the allocation of that loading between the various sources that contribute the pollutant to the water body. These calculations are required under Section 303 of the Federal Clean Water Act for any water body determined not to be attaining its uses (water supply, recreation, aquatic life).

Recent special studies include Falls of the Neuse Reservoir, Jordan Lake (B. Everett Jordan Reservoir) and High Rock Lake. The data collected will be used for analysis of water quality trends and model development/calibration (TMDLs). Other lakes have been monitored intensively to evaluate lake restoration attempts. Merchants Millpond, Big Lake, and Lake Wheeler have been monitored to assess the effects of aquatic weed control measures. Belews, Hyco and Mayo continue to be monitored because of selenium contamination. Lake Wylie was intensively monitored in 1989 and 1990 in response to problems associated with eutrophication and the results were used to implement a nutrient management strategy in the watershed.

Of the 160 reservoirs routinely sampled, 95 lakes classified Water Supply (WS) are reviewed in this report (Figure 1.1 and Table 1.1). While this report discusses only 95 water supply reservoirs, there are 101 reservoirs classified as WS that have been sampled by DWQ over the years. Some lakes classified as WS were not sampled during the 1995-2005 review period due to resource constraints.

***Figure 1.1. Water Supply Reservoirs Sampled by DWQ as Part of the Ambient Lakes Monitoring Program.***

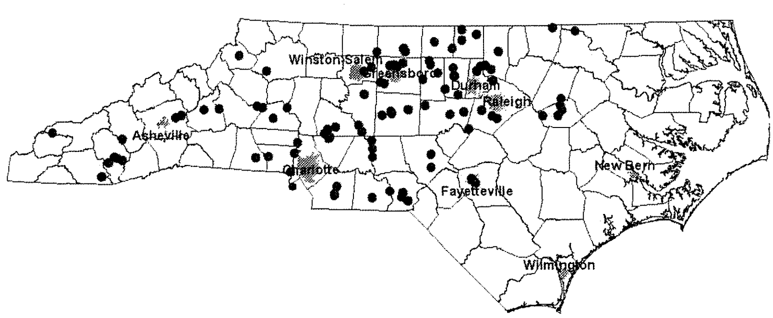


Figure 1.1 presents the distribution of the 95 lakes, while Table 1.1 provides data on characteristics, classification, and sampling history for each lake. Eighty-five of these water supplies are located in the piedmont with ten located in mountain basins. None of these surface water supplies are located in the coastal area.

Sampling for the ALMP has normally occurred in June through August targeting the critical time of year for algal activity in most lakes. Typically, 30 to 35 lakes are sampled monthly in the summer.

The number of stations per lake varies based on the morphology of the lake. Sampling may be more frequent if a special study for permitting or TMDL development is occurring.

Table 1.2 lists the parameters routinely sampled as part of the ALMP. There are 59 parameters that have numeric standards in freshwater, 29 of those parameters have standards specific to water supplies and only five WS specific parameters are regularly monitored due to resource constraints (Table 1.3).

***Table 1.1. Water Supply Reservoirs Sampled by DWQ (Jan. 1995 – May 2005)***

| *Basin/ Water body* | Classification | Mean Depth (feet) | Volume ($10^6 m^3$) | Watershed Area ($mi^2$) | Sampling Dates* (month/year) | Number of Times Sampled |
|---|---|---|---|---|---|---|
| ***BROAD*** | | | | | | |
| ***Kings Mountain Reservoir*** | WS-III CA | 46 | 7.4 | 65.3 | 8/1989 - 5/2005 | 16 |
| ***CAPE FEAR*** | | | | | | |
| ***Bonnie Doone Lake*** | WS-IV | 3 | 0.1 | 3 | 8/1993 - 8/2003 | 7 |
| ***Cane Creek Reservoir*** | WS-II HQW NSW CA | 7 | 11.0 | 32 | 8/1990 - 8/2003 | 11 |
| ***Carthage City Lake*** | WS-III CA | 3 | 0.1 | 27 | 8/1991 - 8/2003 | 8 |
| ***Glenville Lake*** | WS-IV CA | 8 | 0.2 | 10 | 8/1991 - 8/2003 | 7 |
| ***Graham-Mebane Reservoir*** | WS-II HQW NSW CA | 10 | 8.7 | 66 | 8/1993 - 8/2003 | 7 |
| ***Harris Lake*** | WS-V | 20 | 10.1 | 70 | 8/1987 - 8/2003 | 13 |
| ***High Point Lake*** | WS-IV CA | 16 | 4.8 | 60 | 7/1981 - 8/2003 | 29 |
| ***Jordan Lake*** | WS-IV B NSW CA | 16 | 929.6 | 1689 | 7/1982-5/2005 | 128 |
| ***Kornbow Lake*** | WS-IV | 7 | 0.3 | 5 | 8/1993 - 8/2003 | 7 |
| ***Lake Brandt*** | WS-III NSW CA | 7 | 84.0 | 40 | 7/1981 - 8/2003 | 10 |
| ***Lake Cammack (Burlington Reservoir)*** | WS-II HQW NSW CA | 13 | 12.2 | 28 | 8/1981 - 8/2003 | 10 |
| ***Lake Higgins*** | WS-III NSW CA | 12 | 3.0 | 11 | 8/1990 - 8/2003 | 8 |
| ***Lake Hunt*** | WS-III B NSW CA | 33 | 2.8 | 5 | 7/1981 - 8/2003 | 17 |
| ***Lake Mackintosh*** | WS-IV NSW CA | 59 | 29.0 | 129 | 8/1993 - 8/2003 | 14 |
| ***Lake Ramseur (Sandy Creek Reservoir)*** | WS-III CA | 21 | 1.5 | 55 | 8/1992 - 8/2003 | 8 |
| ***Lake Townsend*** | WS-III NSW CA | 10 | 25.0 | 105 | 8/1990 - 8/2003 | 8 |
| ***Mintz Pond*** | WS-IV | 5 | 0.3 | 6 | 8/1993 - 8/2003 | 7 |

## *Table 1.1. Water Supply Reservoirs Sampled by DWQ (Jan. 1995 – May 2005)*

| Basin/ Water body | Classification | Mean Depth (feet) | Volume ($10^6 m^3$) | Watershed Area ($mi^2$) | Sampling Dates* (month/year) | Number of Times Sampled |
|---|---|---|---|---|---|---|
| *Oak Hollow Lake* | WS-IV CA | 21 | 11.0 | 55 | 7/1981 - 8/2003 | 25 |
| *Old Town Reservoir* | WS-III HQW CA | 13 | 0.2 | 0.4 | 9/1988 - 8/2003 | 16 |
| *Pittsboro Lake* | WS-IV NSW | 3 | 0.02 | 8 | 8/1981 - 8/2003 | 9 |
| *Reidsville Lake* | WS-III NSW CA | 20 | 0.04 | 53 | 7/1981 - 8/2003 | 10 |
| *Rocky River Reservoir* | WS-III CA | 18 | 1.6 | 23 | 8/1991 – 8/2003 | 8 |
| *Stoney Creek Reservoir (Lake Burlington)* | WS-II HQW NSW CA | 7 | 1.5 | 110 | 7/1990 – 8/2003 | 8 |
| *University Lake* | WS-II HQW NSW CA | 5 | 2.6 | 29 | 8/1990 – 8/2003 | 8 |
| *CATAWBA* | | | | | | |
| *Bessemer City Lake* | WS-II HQW CA | 15 | 10.0 | 0.02 | 7/1990 - 8/2002 | 5 |
| *Lake Hickory* | WS-IV, V B CA | 33 | 17.0 | 1310 | 8/1981 - 8/2002 | 14 |
| *Lake James* | WS-IV, V B Tr | 46 | 36.9 | 380 | 8/1981 - 8/2002 | 18 |
| *Lake Norman* | WS-IV B CA | 33 | 131.5 | 1790 | 8/1981 - 8/2002 | 11 |
| *Lake Rhodhiss* | WS-IV B CA | 20 | 36.7 | 1090 | 8/1981 - 8/2002 | 22 |
| *Lake Tahoma* | WS-II B Tr HQW | 30 | 0.7 | 23 | 8/1990 - 8/2002 | 5 |
| *Lake Wylie (NC Portion)* | WS-IV, V B CA | 23 | 35.3 | 3020 | 8/1981 - 8/2002 | 37 |
| *Lookout Shoals Lake* | WS-IV, V B CA | 30 | 4.6 | 1450 | 8/1981 - 8/2002 | 12 |
| *Mountain Island Lake* | WS-IV B CA | 16 | 71.0 | 1860 | 8/1981 - 8/2002 | 11 |
| *Newton City Lake* | WS-III CA | 17 | 10.0 | 0.1 | 8/1992 - 8/2002 | 4 |
| *FRENCH BROAD* | | | | | | |
| *Allen Creek Reservoir* | WS-I Tr HQW | 46 | 3.3 | 13 | 8/1990 - 8/2002 | 13 |
| *Beetree Reservoir* | WS-I HQW | 82 | 1.9 | 7.7 | 7/1990 – 8/1997 | 5 |
| *Burnett Reservoir* | WS-I HQW | 39 | 22.0 | 2.3 | 7/1990 - 8/2002 | 8 |
| *LITTLE TENNESSEE* | | | | | | |
| *Bear Creek Reservoir* | WS-III B Tr | 108 | 5.6 | 75 | 7/1988 - 8/2004 | 8 |
| *Cedar Cliff Lake* | WS-III B Tr | 89 | 7.2 | 81 | 7/1988 - 8/2004 | 14 |
| *Fontana Lake* | WS-IV B CA, B Tr, C | 135 | 1782.0 | 1552 | 8/1981 - 8/2004 | 7 |
| *Lake Sequoyah* | WS-III Tr CA | 7 | 0.1 | 14 | 7/1988 - 11/2004 | 11 |
| *Thorpe Reservoir* | WS-III B Tr HQW | 76 | 82.6 | 37 | 7/1988 - 8/2004 | 12 |
| *Wolf Creek Reservoir* | WS-III B Tr HQW | 89 | 2.1 | 40 | 7/1988 - 8/2004 | 11 |
| *NEUSE* | | | | | | |
| *Apex Reservoir* | WS-III NSW CA | 10 | 0.3 | 2.3 | 9/1991 - 7/2000 | 3 |
| *Buckhorn Reservoir* | WS-V NSW | 7 | | 155 | 8/1988 - 5/2005 | 4 |
| *Corporation Lake* | WS-II HWQ NSW CA | 3.3 | 0.9 | 41 | 8/1988 - 8/2000 | 6 |
| *Falls of the Neuse Reservoir* | WS-IV B NSW CA | 16 | 177.0 | 770 | 4/1983 - 5/2005 | 88 |
| *Lake Ben Johnson* | WS-II HWQ NSW CA | 5 | 0.02 | 65 | 8/1988 - 8/200 | 6 |

## *Table 1.1. Water Supply Reservoirs Sampled by DWQ (Jan. 1995 – May 2005)*

| *Basin/ Water body* | Classification | Mean Depth (feet) | Volume ($10^6 m^3$) | Watershed Area ($mi^2$) | Sampling Dates* (month/year) | Number of Times Sampled |
|---|---|---|---|---|---|---|
| *Lake Benson* | WS-III NSW CA | 10 | 3.6 | 65 | 7/1981 - 5/2005 | 12 |
| *Lake Butner (Lake Holt)* | WS-II HWQ NSW CA | 30 | 1.4 | 30 | 8/1988 - 8/2000 | 11 |
| *Lake Michie* | WS-III NSW CA | 26 | 16.0 | | 8/1988 - 8/2000 | 5 |
| *Lake Orange* | WS-II HWQ NSW CA | 13.1 | 0.3 | 10 | 8/19881 - 7/2000 | 5 |
| *Lake Rogers* | WS-II HWQ NSW CA | 9 | 0.5 | 17 | 8/1991 - 8/2000 | 5 |
| *Lake Wheeler* | WS-III NSW | 13 | 8.0 | 28 | 07/1981 - 8/2000 | 9 |
| *Lake Wilson* | WS-III NSW | 5 | 0.7 | 40 | 8/1991 - 5/2005 | 6 |
| *Little River Reservoir* | WS-II HWQ NSW CA | 25 | 18.0 | 98 | 7/1988 - 8/2000 | 17 |
| *Toisnot Reservoir* | WS-II HQW NSW CA | 5 | 0.1 | 50 | 8/1988 - 8/2000 | 6 |
| *Wiggins Mill Reservoir* | WS-III NSW CA | 2 | 0.6 | 237 | 8/1988 - 5/2005 | 7 |
| ***NEW*** | | | | | | |
| *ASU Lake* | WS-II Tr HQW CA | 112 | 0.7 | 34.4 | 7/1992 - 8/2003 | 7 |
| ***ROANOKE*** | | | | | | |
| *Belews Lake* | WS-IV B | 49 | 228.0 | 46 | 7/1981 - 8/2004 | 24 |
| *Farmer Lake* | WS-II HQW CA | 18 | 6.5 | 48 | 8/1991 - 11/2004 | 19 |
| *Hyco Lake* | WS-V B | 20 | 99.0 | 188 | 7/1983 - 9/2004 | 15 |
| *Kernersville Lake* | WS-IV CA | 16 | 0.4 | 3.5 | 8/1988 - 8/2004 | 13 |
| *Lake Gaston (NC Portion)* | WS-IV, V B CA | 95 | 512.0 | 8239 | 8/1981 - 8/2004 | 18 |
| *Lake Roxboro* | WS-II B HQW | 20 | 11.0 | 24 | 8/1988 - 8/2004 | 16 |
| *Mayo Reservoir* | WS-V | 30 | 105.0 | 51 | 7/1983 - 9/2004 | 13 |
| *Roanoke Rapids Lake* | WS-IV B CA | 16 | 96.0 | 8294 | 8/1981 - 8/2004 | 13 |
| *Roxboro City Lake* | WS-II HQW CA | 12 | 0.3 | 196 | 7/1988 - 11/2004 | 12 |
| ***TAR-PAMLICO*** | | | | | | |
| *Lake Devin* | WS-II HQW NSW CA | 16 | 1.6 | 1.2 | 8/1989 - 8/2002 | 8 |
| *Tar River Reservoir* | WS-IV B NSW CA | 20 | 16.0 | 774.9 | 7/1989 - 8/2002 | 8 |
| ***YADKIN-PEE DEE*** | | | | | | |
| *Badin Lake* | WS-IV B CA | 46 | 344.0 | 4116 | 7/1981 - 10/2002 | 18 |
| *Blewett Falls Lake* | WS-II HQW CA | 39 | 8.3 | 6784 | 7/1991 – 8/1999 | 10 |
| *Bunch Lake* | WS-II HQW CA | 10 | 0.04 | 2 | 7/1989 - 8/2001 | 19 |
| *High Rock Lake* | WS-IV, V B CA | 16 | 314.0 | 3929 | 7/1981 - 5/2005 | 33 |
| *Kannapolis Lake* | WS-IV, V B CA | 16 | 5.2 | 11 | 8/1989 - 8/2000 | 5 |
| *Kerr Scott Reservoir* | WS-IV B Tr | 39 | 189.0 | 3348 | 9/1981 - 8/2002 | 16 |
| *Lake Concord* | WS-IV CA | 12 | 1.3 | 4 | 8/1989 - 7/2000 | 4 |
| *Lake Corriher* | WS-IV CA | 8 | 0.2 | 2 | 8/1989 – 8/1999 | 5 |
| *Lake Fisher* | WS-IV CA | 15 | 3.2 | 78 | 8/1989 - 8/2000 | 5 |
| *Lake Lee* | WS-IV CA | 5 | 9.5 | 51 | 8/1989 - 8/2000 | 5 |

## *Table 1.1. Water Supply Reservoirs Sampled by DWQ (Jan. 1995 – May 2005)*

| *Basin/ Water body* | Classification | Mean Depth (feet) | Volume ($10^6 m^3$) | Watershed Area ($mi^2$) | Sampling Dates* (month/year) | Number of Times Sampled |
|---|---|---|---|---|---|---|
| ***Lake Lucas (Back Creek Lake)*** | WS-II HQW CA | 13 | 5.0 | 16 | 7/1989 - 8/2002 | 9 |
| ***Lake Monroe*** | WS-IV CA | 18 | 1.8 | 9 | 8/1989 - 8/2000 | 5 |
| ***Lake Reese*** | WS-III CA | 16 | 0.9 | 100 | 7/1989 - 8/2002 | 13 |
| ***Lake Thom-A-Lex*** | WS-III CA | 26 | 7.8 | 39 | 7/1981 - 8/2002 | 17 |
| ***Lake Tillery*** | WS-IV B CA | 33 | 207 | 4834 | 7/1981 – 8/1999 | 10 |
| ***Lake Twitty (Lake Stewart)*** | WS-III CA | 18 | 7.6 | 36 | 8/1989 - 8/2000 | 5 |
| ***Lake Wright*** | WS-II HQW CA | 10 | 0.3 | 2 | 8/1989 - 8/1999 | 5 |
| ***McCrary Lake*** | WS-II HQW CA | 10 | 0.9 | 1 | 7/1989 - 8/2001 | 10 |
| ***Roberdel Lake*** | WS-III CA | 10 | 10.0 | 140 | 8/1989 - 8/2000 | 4 |
| ***Rockingham City Lake*** | WS-III CA | 2 | 0.02 | 20 | 8/1992 - 8/2000 | 4 |
| ***Salem Lake*** | WS-III CA | 18 | 0.8 | 26 | 7/1981 - 8/2002 | 17 |
| ***Tuckertown Reservoir*** | WS-IV B CA | 33 | 289 | 4210 | 7/1981 – 8/1999 | 9 |
| ***Wadesboro City Pond (City Pond)*** | WS-II HQW CA | 8 | 0.1 | 9 | 8/ 1989 - 8/200 | 5 |
| ***Water Lake*** | WS-II HQW CA | 10 | 0.06 | 20 | 8/1989 - 8/2000 | 10 |

* *Sampling was normally conducted during June, July, and August.*

## *Table 1.2. Parameters Routinely Sampled by DWQ at Water Supply Reservoirs*

| | | |
|---|---|---|
| **Physical Measurements (at 1 meter increments from the surface to the bottom of the lake)** | | |
| Dissolved Oxygen | Secchi depth | pH |
| Water Temperature | Conductivity | |
| **Metals (collected at the surface)** | | |
| Cadmium | Copper | Calcium * |
| Iron | Manganese | Zinc |
| Chromium, Total | Lead | Magnesium * |
| Nickel | | |
| **Water Chemistry (collected from Photic Zone (from surface to 2 times the Secchi depth)** | | |
| Turbidity | Total Residue | Total Suspended Solids |
| Total Dissolved Solids | | |
| **Nutrients (Photic Zone composite samples and Bottom grab samples)** | | |
| Ammonia | Total Kjeldahl Nitrogen | Total Phosphorus |
| Nitrate/Nitrite | | |
| **Biological** | | |
| Chlorophyll *a* (Photic Zone) | Phytoplankton (Photic Zone) | |
| Fecal Coliform Bacteria (Surface Grab) (colonies/100 ml) only in lakes classified B | | |

* *Calcium and Magnesium are used to calculate Total Hardness (mg/L)*

The ALMP is conducted by the Intensive Survey Unit with a staff of seven people (including supervisor); only two are dedicated to sampling lakes. The Intensive Survey Unit also conducts a variety of physical and chemical sampling to support permitting, compliance, modeling, TMDL development, emergency response, reclassifications and regional investigations in lakes, rivers, streams and estuaries. At times, the Winston-Salem Regional Office assists with lakes monitoring.

***Table 1.3. Parameters with Water Supply Standards***

**(Bold indicates parameters routinely sampled as part of Ambient Lakes monitoring)**

| | | |
|---|---|---|
| 1,1,2,2-Tetrachlorethane | Chlorinated Benzenes | PAH |
| 2,4-D | DDT | PCB |
| Aldrin | Dieldrin | Phenolic Compounds |
| Arsenic | Dioxin | Silvex |
| Barium | **Hardness** | Sulfates |
| Benzene | Hexachlorobutadiene | Tetrachloroethylene |
| Beryllium | Manganese | **Total dissolved solids** |
| Carbon Tetrachloride | Methylene Blue Active Substances | Trichloroethylene |
| Chlordane | **Nickel** | Vinyl chloride |
| **Chloride** | **Nitrate (nitrate/nitrite)** | |

## *1.3. Water Supply Classifications & Standards*

Surface water classifications are designations applied to streams, rivers and lakes, and are intended to define the best uses to be protected within these waters (for example swimming, recreation, drinking water supply, etc.). The surface water standards are designed to protect the water quality based on the classifications for a variety of ecological and human health reasons.

For surface waters used as water supplies, there are five classifications: WS-I, WS-II, WS-III, WS-IV, and WS-V. All water supply classifications except WS-V carry additional restrictions on treated wastewater discharges and land use activities based on development in the watershed (Table 1.4). Note that some portions of the WS watersheds carry additional restrictions due to their proximity to the water intakes. Those areas are designated by CA, which stands for "critical area".

Twenty-eight of the WS lakes are also classified B, which recognizes that they have organized swimming occurring on a regular basis in areas of those lakes. Management strategies associated with these waters include discouraging wastewater discharges and storm drains.

Some WS lakes are supplementally classified as nutrient sensitive waters (NSW). These lakes are in watersheds that the EMC has determined to be experiencing nutrient over-enrichment and that need additional management to protect and restore water quality.

## Table 1.4. Land Use and Discharge Requirements Associated with WS Classifications[1].

| | WS-I | WS-II | WS-II | WS-III | WS-III | WS - IV | WS - IV | WS - V |
|---|---|---|---|---|---|---|---|---|
| **Watershed Characteristics** | Natural or undeveloped watersheds | Lightly developed | Lightly developed | Low or moderately developed | Low or moderately developed | Moderate to high development | Moderate to high development | Upstream and draining to Class WS-IV waters |
| **Number of Lakes Sampled in this Class** | 3 | 24 | 2 | 23 | 6 | 27 | 8 | 4 |
| **Area Affected** | Entire Watershed | 1/2 Mile Critical Area (CA) | Rest of Watershed | 1/2 Mile CA | Rest of Watershed | 1/2 Mile CA | Rest of Watershed | River Segment |
| **Wastewater Discharge Allowed** | None Allowed | General Permits | | | Domestic & Non-Process Industrial | | | |
| **Permit Limits** | Not Applicable | Per HQW Rules | | Standard Rules | | | | |
| **Low Density Option (du = dwelling unit; ac = acre)** | None ---- Underdeveloped | 1 du/2 ac or 6 percent Built Upon Area | 1 du/2 ac or 12 percent Built Upon Area | | 1 du/2 ac or 24 percent Built Upon Area | | | No Restrictions |
| **High Density Option** | None ---- Underdeveloped | 6 - 24 percent Built Upon Area | 12 - 30 percent Built Upon Area | | 24 - 50 percent Built Upon Area | | 24 - 70 percent Built Upon Area | No Restrictions |
| **Stream Setbacks for Impervious Surfaces** | Not Applicable | Low Density – 30' High Density - 100' | | | | | | None Required |
| **Erosion & Sedimentation Controls** | More Stringent Rules Apply | | | Standard Rules | | | | |
| **Agriculture BMPs Mandated** | Yes | | | | | | | |
| **Forestry BMPs Mandated** | Yes | | | | | | | |
| **Transportation BMPs Mandated** | Stricter NC Div. Of Land Resources Erosion Controls Apply | | | Yes | | | | Applied As Practical |
| **Landfills Allowed** | None Allowed | No New Landfills | No New Discharging Landfills | No New Landfills | No New Discharging Landfills | No New Landfills | Yes | No Specific Restrictions |

[1] Water Supply Classification Rules are found in the 15A NCAC 2B .0100s and .0200s. Additional information is available at http://h2o.enr.state.nc.us/csu/index.html

Fourteen of the WS reservoirs sampled in the Cape Fear River Basin are regulated under the NSW rules for the Haw River and Jordan Reservoir drainage areas (Table 1.5). All of the Neuse (17) and Tar-Pamlico (2) Water Supply reservoirs sampled by DWQ are NSW. An outline of the management strategies and rules governing these waters is presented in Table 1.6. They include permit limits and stream buffer requirements.

Other supplemental classifications that impact management and regulations related to water supplies and their watersheds include High Quality Waters (HQW) and Trout (Tr). All WS-I and WS-II are classified as HQW (n=29) and that classification is reflected in the management strategies presented in Table 1.4. The Trout classification is reserved for waters that are home to naturally propagating trout and stocked trout. Trout flourish in colder waters and are more sensitive to some pollutants than most other fish species. Therefore, water quality standards for dissolved oxygen, temperature, turbidity, chlorophyll-a, cadmium, and toluene are more stringent.

***Table 1.5. Water Supply Lakes Currently Classified as NSW by River Basin***

| | |
|---|---|
| **Cape Fear River Basin** | |
| Burlington Reservoir | Cane Creek Reservoir |
| Graham-Mebane Reservoir | B.E. Jordan Reservoir |
| Lake Brandt | Lake Burlington |
| Lake Higgins | Lake Hunt |
| Lake Mackintosh | Lake Townsend |
| Pittsboro Lake | Reidsville Lake |
| Richland Lake | University Lake |
| **Neuse River Basin** | |
| Apex Reservoir | Beaverdam Reservoir |
| Buckhorn Reservoir | Corporation Lake |
| Falls of the Neuse Reservoir | Lake Ben Johnson |
| Lake Benson | Lake Butner |
| Lake Michie | Lake Orange |
| Lake Rogers | Lake Wheeler |
| Lake Wilson | Little River Reservoir |
| Toisnot Reservoir | West Fork Eno River Reservoir |
| Wiggins Mill Reservoir | |
| **Tar-Pamlico River Basin** | |
| Lake Devin | Tar River Reservoir |

## *1.4. Impaired Waters Designation*

Section 303(d) of the Clean Water Act (CWA) requires states to develop a list of waters not meeting water quality standards or which have impaired uses. Listed waters must be prioritized, and a management strategy or total maximum daily load (TMDL) must subsequently be developed for all listed waters. Uses that are evaluated for development of this list include water supply, aquatic life, and recreation. This list must be submitted to EPA every 2 years for their approval. More information on this program is available at http://h2o.enr.state.nc.us/tmdl/.

## *Table 1.6. NSW Requirements Related to Discharges and Land Use in the Neuse, Tar-Pamlico and Cape Fear River Basins.*

| | Neuse River Basin | Tar-Pamlico River Basin | Cape Fear River Basin |
|---|---|---|---|
| **Area Affected** | Entire watershed | Entire watershed | Haw River & Jordan Reservoir Drainage |
| **Wastewater Discharge Allowed** | Per WS Classification | | |
| **Permit Limits** | Yes [1] | Yes [2] | Yes [3] |
| **Low Density Option** | Per WS Classification | | |
| **High Density Option (includes additional stormwater controls)** | Per WS Classification | | |
| **Stream Setbacks for Impervious Surfaces** | Riparian Buffer Protection Rules 50' wide riparian buffer adjacent directly adjacent to surface waters | | Per WS Classification |
| **Erosion & Sedimentation Controls** | Standard Rules | | |
| **Agriculture Best Management Practices Mandated** | Required either as standard BMPs or as part of Collective Local Strategy | Required to collectively limit nutrient loading to the estuary to achieve target reductions | Standard Rules |
| **Forestry Best Management Practices Mandated** | Per Forest Practices Guidelines | | |
| **Transportation Best Management Practices Mandated** | Per WS Classification | | |
| **Landfills Allowed** | Per WS Classification | | |

**1. NEUSE RIVER BASIN:**

Nitrogen Limits: Originally effective August 1, 1998, the nitrogen discharge limit reduces the nitrogen from point sources by 30 percent compared to 1995 levels. The overall nitrogen discharge limit is 2.8 million pounds per year. Limits in terms of pounds per year are called "mass-based limits." The overall nitrogen discharge limit is divided among three different groups of dischargers as follows:

- Dischargers with permitted flows greater than or equal to 500,000 gallons per day or 0.5 million gallons per day (MGD) downstream of Falls Lake dam have a combined limit of 2.45 million pounds per year.
- Dischargers with permitted flows greater than or equal to 0.5 MGD upstream of the dam have a combined limit of 444,000 pounds per year.
- Dischargers with permitted flows less than 0.5 MGD have a combined limit of 280,000 pounds per year.

Phosphorus Limits: 2.0 mg/L concentration limit on phosphorus throughout basin

**2. TAR-PAMLICO RIVER BASIN**

Tar-Pamlico Basin Association Members - As a coalition, the goal is to decrease total nitrogen load to the estuary by 30 percent from 1991 levels along with no increases in phosphorus loads. Nutrient exceedances follow the offset payment approach with offset rates adjusted based on basin-specific agricultural BMP cost-effectiveness data. Non-Tar-Pamlico Basin Association Members are placed on restrictions; all discharges >0.5 MGD must meet 6 mg/L TN and 1 mg/L TP limits within 5 years. Any new loading from new or expanding facilities are mitigated using the offset payment method established for the Tar-Pamlico Association Members.

**3. CAPE FEAR RIVER BASIN**

Limits of 5.5 mg/L TN and 2.0 mg/L TP for qualifying facilities discharging >0.5MGD into the Jordan Reservoir/Haw River watershed (Clean Water Responsibility Act of 1997). Most of the facilities were granted an extension by the EMC (Senate Bill 1366) and were required to develop a calibrated nutrient response model. That model has been developed and rules are being developed to implement the limits indicated by the model.

There are ten water supply lakes listed for impaired aquatic life use support (Table 1.7). Six of the lakes are listed for impaired biological integrity due to impairments in the streams feeding them. Several have been recently delisted due to improvements in water quality. Hyco Lake has been removed due to the rescinding of the fish consumption advisory for selenium. Pittsboro and Roanoke Rapids Lakes are listed for aquatic weeds and as aquatic weeds are not considered a pollutant, no TMDL is required.

***Table 1.7. Water Supply Lakes Listed as Impaired on the 2004 Impaired Waters List.***

| Basin/Water Supplies | Year Listed | Reason Listed | TMDL Status |
|---|---|---|---|
| **Cape Fear** | | | |
| Bonnie Doone Lake | 1998 | Impaired biological integrity | Included in impaired stream segment (Little Cross Creek). Not scheduled. |
| B.E. Jordan Reservoir – New Hope & Morgan Cr Arms | 2002 | Chlorophyll a | Draft TMDL completed |
| Glenville Lake | 2000 | Impaired biological integrity | Included in impaired stream segment (Little Cross Creek). Not scheduled. |
| Kornbow Lake | 1998 | Impaired biological integrity | Included in impaired stream segment (Little Cross Creek). Not scheduled. |
| Mintz Pond | 1998 | Impaired biological integrity | Included in impaired stream segment (Little Cross Creek). Not scheduled. |
| Pittsboro Lake | 1998 | Aquatic Weeds | To be shifted to Category 4c (Impairment not caused by a pollutant) –does not require a TMDL |
| **Neuse** | | | |
| Buckhorn Reservoir | 1998 | Impaired biological integrity | Included in impaired stream segment (Contentnea Creek). Not scheduled. |
| **Roanoke** | | | |
| Hyco Lake | 1998 | Fish Advisory – Selenium | Delisted 2004 - Fish Advisory rescinded in 2001. |
| Roanoke Rapids Lake | 1998 | Aquatic Weeds | To be shifted to Category 4c (Impairment not caused by a pollutant) –does not require a TMDL |
| **Yadkin-Pee Dee** | | | |
| High Rock Lake | 2004 | Turbidity & Chlorophyll a | In Scoping Phase prior to TMDL development |

B.E. Jordan Reservoir was listed for chlorophyll-a violations in 2002 and a draft TMDL was completed in 2005. Development of an implementation strategy is currently underway. High Rock Lake is also listed for chlorophyll a, as well as, turbidity. DWQ is currently doing additional monitoring and working with the High Rock Lake Technical Advisory Committee composed of agency staff and other stakeholders to develop the monitoring and modeling strategy for TMDL development. It is expected that TMDL modeling will begin in 2009 or 2010.

There are no lakes currently listed as not supporting water supply uses. Water supply use support is assessed using information from the seven Division of Environmental Health regional water treatment plant (WTP) consultants. Each January, the WTP consultants are asked to submit a spreadsheet listing closures and water intake switch-overs for all water treatment plants in their region. This spreadsheet describes the length and time of the event, contact information for the WTP, and the reason for the switch-overs and closures. When the closures/switches are due to water quality, then they are considered in determining if the uses of the lake (recreation, water supply, aquatic life) are being protected.

## 1.5. Water Supply Protection Program

The EMC and DWQ have administered a Water Supply Protection Program since 1986. Under the Water Supply Protection Rules, all water supply watersheds are to have ordinances, maps and a management plan in place to protect the water supplies. DWQ is conducting a review of the program and preparing for another audit of all water supplies covered under the rules.

## 1.6. Division of Environmental Health Surface Water Assessment Program

The 1996 Federal Safe Drinking Water Act (SDWA) Amendments required that all states establish Source Water Assessment Programs in order to determine the susceptibility of public water supply sources to contamination. This new focus in the SDWA promotes the prevention of drinking water contamination as a cost-effective means to provide reliable, long-term, and safe drinking water sources for public water supply systems. Specifically, Section 1453 of the SDWA Amendments required that states develop and implement a Source Water Assessment Program (SWAP) to delineate source water assessment areas, inventory potential contaminants in these areas, and determine the susceptibility of each public water supply to contamination.

The Public Water Supply (PWS) Section of the Division of Environmental Health in DENR is responsible for SWAP in North Carolina. The PWS Section received EPA approval for their SWAP Plan in November 1999. The SWAP Plan, entitled "North Carolina's Source Water Assessment Program Plan," fully describes the methods and procedures used to delineate and assess the susceptibility of more than 9,000 wells and approximately 207 surface water intakes. The SWAP Plan is available at: http://www.deh.enr.state.nc.us/pws/swap.

In April 2004, the PWS Section completed source water assessments for all drinking water sources and generated reports for the public water supply systems using these sources. In April 2005, a second round of assessments were completed. The ratings are available at the above-mentioned web site, either through the interactive mapping tool or compiled in a written report for each public water supply system.

# Section 2. Methodology

For the purposes of this report, DWQ ambient lakes data from January 1995 through May 2005 were reviewed. Over that time period, DWQ sampled 97 lakes with the water supply classifications (WS-I, WS-II, WS-III, WS-IV, and WS-V). West Fork Eno Reservoir was only recently filled and was only sampled once in May 2005. Beaverdam Lake has been included in the analysis of Falls of the Neuse Reservoir. Therefore, only 95 lakes are discussed in this report.

As noted earlier, lakes are sampled once every five years unless a special study is conducted. As the 2005 Drinking Water Reservoir Protection Act is focused on eutrophication in water supplies, this analysis is of those standards related to eutrophication: chlorophyll a, dissolved oxygen, pH, and turbidity. The discussions for individual lakes found in Appendix 2 may include discussion of water quality problems associated with parameters that have no standards such as aquatic weeds.

Eutrophication-related standards for WS waters are presented in Table 2.1.

***Table 2.1. Surface Water Quality Standards Related to Eutrophication***

| Parameter | Standard for Non-Trout Waters | Standard for Trout Waters |
|---|---|---|
| Chlorophyll a | Not greater than 40 ug/L | Not greater than 15 ug/L |
| Dissolved oxygen | Not less than 4 mg/L | Not less than 6 mg/L |
| pH | Between 6 and 9 except in Swamp Waters then 4.3 Standard Units (SU) | Between 6 and 9 SU |
| Turbidity | 25 Nephelometric Units (NTU) | 10 NTU |

North Carolina does not have standards for nutrients (phosphorus and nitrogen) that result in eutrophication as there are a variety of factors that control a water body's response to nutrients including, but not limited to: size, depth, flow, shape of the lake, and light penetration. When the chlorophyll-a standard was adopted it was based on the determination that an indicator of eutrophication would provide more certainty in determining impacts than nitrogen and phosphorus standards.

Dissolved oxygen (DO), pH and turbidity are also indicators of the potential for eutrophication. During photosynthesis and respiration, DO and pH can increase and decrease due to the chemical reactions taking place. During the normal sampling times for the Ambient Lakes Monitoring Program (usually between 10 AM and 3 PM), peak photosynthesis is occurring resulting in increased oxygen releases by the alga and an increase in pH due to carbon dioxide uptake related to photosynthesis. When DO reaches levels above 10-12 mg/L at summer temperatures, the water becomes supersaturated and fish may experience gas bubble disease if they are unable to escape the supersaturated waters. Gas bubble disease may be fatal or the fish may eventually recover.

Turbidity refers to water clarity. The greater the amount of suspended solids in the water, including algae, the murkier it appears and the higher the turbidity measured. Turbidity measures the scatter of light by the suspended solids as opposed to measuring solids.

Therefore, anything that results in light scattering will increased the turbidity reading. That is why turbidity is considered to be related to eutrophication, the more phytoplankton in the water column, the higher the turbidity reading. Therefore, the major source of turbidity in the open water zone of most lakes is typically phytoplankton. Closer to the shore, clays and silts from shoreline erosion, resuspended bottom sediments and organic detritus from stream and/or discharges not only are usually the major source of turbidity but they actually act to shade the phytoplankton, reducing phytoplankton growth. Dredging operations, channelization, increased flow rates, floods, or even too many bottom-feeding fish (such as carp) may stir up bottom sediments and increase the cloudiness of the water.

In addition to carrying nutrients, high concentrations of particulate matter can modify light penetration, cause shallow lakes and bays to fill in faster, and smother bottom habitats impacting both organisms and eggs. As particles of silt, clay, and other organic materials settle to the bottom, they can suffocate newly hatched larvae and fill in spaces between rocks which could have been used by aquatic organisms as habitat. Fine particulate material also can clog or damage sensitive gill structures, decrease their resistance to disease, prevent proper egg and larval development, and potentially interfere with particle feeding activities. If light penetration is reduced significantly, macrophyte growth may be decreased which would in turn impact the organisms dependent upon them for food and cover. Reduced photosynthesis can also result in a lower daytime release of oxygen into the water. Effects on phytoplankton growth are complex depending on too many factors to generalize.

For the purposes of this review, standards were deemed to be exceeded (not met) when the sample size was 10 or more and more than 10 percent of the samples failed to meet the standard.

# Section 3. Findings and Recommendations

## *3.1. Findings*

### 3.1.1. Eutrophication Related Standards

Using DWQ's Ambient Lakes Monitoring data and some information from the water supply users (Appendix 1), 13 lakes (14 percent) are currently not meeting eutrophication-related water quality standards: Graham-Mebane Reservoir, High Point Lake, Jordan Lake, Stoney Creek Reservoir, Lake Mackintosh, Pittsboro Lake, Lake Rhodhiss, Cedar Cliff Lake, Lake Sequoyah, Falls of the Neuse Reservoir, High Rock Lake, Lake Lee, and Lake Twitty (Table 3.1).

***Table 3.1. Water Supply Reservoirs Sampled by DWQ Not Meeting All Eutrophication-Related Standards (Jan 1995-May 2005) with Current Management Strategies***

| Lake | Standard Not Met in >10% of Samples | Current Actions |
|---|---|---|
| **Cape Fear River Basin** | | |
| Graham-Mebane Reservoir | Chlorophyll-a | NSW |
| High Point Lake | Chlorophyll-a | Adding to Impaired Waters List |
| Jordan Lake | Chlorophyll-a | NSW, TMDL |
| Lake Mackintosh | Chlorophyll-a | NSW |
| Pittsboro Lake | Turbidity | NSW, TMDL (aquatic plants) |
| Stoney Creek Reservoir | Turbidity | NSW |
| **Catawba River Basin** | | |
| Lake Rhodhiss | pH | Adding to Impaired Waters List |
| **Little Tennessee River Basin** | | |
| Cedar Cliff Lake | pH | Additional sampling was conducted that did not find similar pH problems. No further action has been planned. |
| Lake Sequoyah | pH | Local Efforts Underway |
| **Neuse River Basin** | | |
| Falls of the Neuse Reservoir | Turbidity | NSW, Special study underway |
| **Yadkin River Basin** | | |
| High Rock Lake | Chlorophyll-a, pH, turbidity | TMDL |
| Lake Lee | pH | Additional sampling is planned during 2006 |
| Lake Twitty (Lake Stewart) | pH | Additional sampling is planned during 2006 |

Table 3.1 indicates activities currently underway, which are intended to reduce nutrient inputs. Most of the Cape Fear River basin lakes and Falls of the Neuse Reservoir in the Neuse River basin are classified as NSW. The NSW classification carries with it management strategies designed to reduce nutrient inputs based on site-specific requirements. These management strategies are revisited periodically through the basinwide process to determine if the strategy is working and allow for adjustments.

Those lakes that are listed on the Impaired Waters List may require the development of TMDLs that identify the allowable nutrient concentrations as well as how much reduction is required of each source. TMDLs are used to develop permit limits and to target nonpoint source control activities. They may also result in the development of rules to provide additional controls of point and nonpoint sources.

Additional sampling was conducted on Cedar Cliff Lake during 1999 to determine if the low pH values were indicative of on-going impairment. Subsequent sampling indicates pH within the standards and no additional management is recommended at this time. Lakes Lee and Twitty are targeted during the 2006 sampling period for additional sampling to provide additional data for determining causes and sources of impairment.

In the case of some water supply lakes (High Point Lake, Oak Hollow Lake, Lakes Lucas, Twitty, Hickory and Rhodhiss), algal bloom related problems have been significant enough to require additional treatment either at the treatment facility (addition of carbon filters for example) or in the lake (destratification systems). The destratification systems used in Oak Hollow, Lucas and Twitty prevent algae from remaining within the photic zone and multiplying while maintaining dissolved oxygen and pH at normal levels, therefore chlorophyll-a, dissolved oxygen and pH values met the standards even though nutrient concentrations are sufficient to cause blooms.

The sources of the nutrients fueling the algal blooms include point and nonpoint sources. Due to the protected nature of most water supply watersheds, nonpoint sources of rural origin appear to be the largest source of threat. The Basinwide process continues to work with local stakeholders to address these issues.

Additional information on the lakes with exceedances is provided in Appendix 2.

### 3.1.2. Other Water Quality Concerns

In the process of preparing this document, information on all the water supply lakes was reviewed and it appears that, in addition to nutrient over-enrichment (algal blooms), aquatic weeds and sediment are also major problems for water supply reservoirs (Table 3.2 and Appendix 2). Sedimentation is a major problem in some of the watersheds, although it is not always indicated by in-lake turbidity. While turbidity gives some idea of sediment, it does not provide a good measure of the amount of sediment coming into a system and being deposited. Therefore, DWQ's results include field observations and are probably an underestimation of the true impact of sedimentation within North Carolina's lakes. This is especially true in the Yadkin-Pee Dee River Basin where highly erodable soils and heavy development pressures result in the Yadkin River flowing muddy most of the time.

A few lakes had other documented problems, such as Bonnie Doone Lake in the Cape Fear Basin where the City of Fayetteville is addressing pesticides in stormwater runoff after finding them in the lake. Some lakes need to be reclassified to recognize the swamp water influences that result in pH below the standard.

***Table 3.2. Potential Causes of Water Quality Concerns in Water Supply Reservoirs Based on DWQ Ambient Lakes Monitoring Results.***

*(Shading indicates that those causes have been identified as problems in each basin.)*

| Basin | Cause | | |
|---|---|---|---|
| | **Aquatic Weeds** | **Sediment** | **Algal Blooms-Nutrients** |
| Broad | | | |
| Cape Fear | (shaded) | | (shaded) |
| Catawba | (shaded) | (shaded) | (shaded) |
| French Broad | | | |
| Little Tennessee | | | (shaded) |
| Neuse | (shaded) | (shaded) | (shaded) |
| New | | | |
| Roanoke | (shaded) | (shaded) | (shaded) |
| Tar-Pamlico | (shaded) | (shaded) | (shaded) |
| Yadkin-Pee Dee | (shaded) | (shaded) | (shaded) |

Aquatic weeds, such as Hydrilla and Parrotfeather, are hardy, fast growing and have caused problems for water supply intakes, boating, swimming and aquatic life throughout the state. These aquatic weeds can take over a water supply within a couple of years, increasing maintenance costs for facilities and ruining the public's experience of their waters. Fourteen WS lakes sampled by DWQ are currently infested with aquatic weeds at levels that require some treatment.

## *3.2. Recommendations*

As is evident from the data review, DWQ's current program does not have sufficient data in most cases to determine with confidence that a water supply is or is not meeting standards. The Ambient Lakes Monitoring program was designed to allow targeting of water bodies for additional sampling based on the limited resources available to support the program. It is possible to conduct large-scale assessments of eutrophication in multiple reservoirs; however, it will require significant additional resources including staff, equipment and laboratory support.

# Appendix 1. Percentage of Samples Not Meeting Eutrophication-Related Water Quality Standards in Water Supply Reservoirs Sampled by DWQ

| Basin & Lake Name | Years Included in Analyses | # of Chl-a Samples | # of DO, ph & Turbidity Samples | Percentage of Samples Not Meeting Each Standard During January 1995 through May 2005 | | | |
|---|---|---|---|---|---|---|---|
| | | | | Chl-a | DO | pH | Turbidity |
| BROAD RIVER | | | | | | | |
| *Kings Mountain Reservoir* | 1995, 2000, 2005 | 12 | 24 | | | | |
| CAPE FEAR RIVER | | | | | | | |
| *Bonnie Doone Lake* | 1998, 2003 | 6 | 6 | | | * | |
| *Cane Creek Reservoir* | 1996, 1998, 2003 | 9 | 27 | * | | * | |
| *Carthage City Lake* | 1998, 2003 | 3 | 6 | | | * | |
| *Glenville Lake* | 1998, 2003 | 2 | 5 | | | * | |
| *Graham-Mebane Reservoir* | 1998, 2003 | 15 | 30 | 27 % | | | |
| *Harris Lake* | 1996, 2003 | 8 | 22 | | | | |
| *High Point Lake* | 1996-1998, 2000-2003 | 12 | 48 | 25 % | | | |
| *Jordan Lake* | 1995-2001, 2005 | 607 | 732 | 27 % | 5 % | 8 % | 8 % |
| *Kornbow Lake* | 1998, 2003 | 3 | 6 | | | | |
| *Lake Brandt* | 1998, 2003 | 9 | 18 | | | | 6 % |
| *Lake Cammack (Burlington Reservoir)* | 1998, 2003 | 6 | 12 | * | | | |
| *Lake Higgins* | 1998, 2003 | 6 | 12 | | | | |
| *Lake Hunt* | 1998, 2003 | 9 | 15 | * | | 7 % | |
| *Lake Mackintosh* | 1996-1998, 2003 | 18 | 72 | 17 % | | | 7 % |
| *Lake Townsend* | 1998, 2003 | 9 | 18 | | | | |
| *Mintz Pond* | 1998, 2003 | 3 | 6 | | | * | |
| *Oak Hollow Lake* | 1996-1998, 2000-2003 | 18 | 63 | | | | |
| *Old Town Reservoir* | 1998, 2003 | 6 | 12 | | | | |
| *Pittsboro Lake* | 1998, 2003 | 6 | 11 | * | | | 27 % |
| *Reidsville Lake* | 1998, 2003 | 6 | 12 | * | | | 8 % |
| *Rocky River Reservoir* | 1998, 2003 | 6 | 12 | * | | | |
| *Sandy Creek Reservoir* | 1998, 2003 | 9 | 18 | * | | | |
| *Stoney Creek Reservoir (Lake Burlington)* | 1998, 2003 | 6 | 12 | | | | 17 % |
| *University Lake* | 1998, 2003 | 6 | 12 | * | | | |
| CATAWBA RIVER | | | | | | | |
| *Bessemer City Lake* | 2002 | 3 | 3 | | | | |
| *Lake Hickory* | 1997, 2002 | 11 | 24 | | | 4 % | |
| *Lake James* | 1997, 2001, 2002 | 18 | 59 | | | | |
| *Lake Norman* | 1997, 2002 | 24 | 48 | | | | |

| Basin & Lake Name | Years Included in Analyses | # of Chl-a Samples | # of DO, ph & Turbidity Samples | Percentage of Samples Not Meeting Each Standard During January 1995 through May 2005 | | | |
|---|---|---|---|---|---|---|---|
| | | | | Chl-a | DO | pH | Turbidity |
| *Lake Rhodhiss* | 2001, 2002 | 23 | 63 | 9 % | | 15 % | |
| *Lake Tahoma* | 2002 | 6 | 6 | | | | |
| *Lake Wylie* | 1997, 2001-2002 | 24 | 90 | 4 % | | 1 % | 1 % |
| *Lookout Shoals Lake* | 1997, 2002 | 9 | 18 | | | | |
| *Mountain Island Lake* | 1995, 1997, 2002 | 21 | 39 | | | | |
| *Newton City Lake* | 2002 | 3 | 3 | | | | |
| FRENCH BROAD RIVER | | | | | | | |
| *Allen Creek Reservoir* | 2002 | 6 | 6 | | | | |
| *Beetree Reservoir* | 1997 | 3 | 3 | | | | |
| *Burnett Reservoir* | 1997, 2002 | 6 | 12 | | | | |
| LITTLE TENNESSEE RIVER | | | | | | | |
| *Bear Creek Reservoir* | 1999, 2004 | 6 | 12 | | | | |
| *Cedar Cliff Lake* | 1996, 1999, 2004 | 6 | 14 | | | 14 % | |
| *Fontana Lake* | 2004 | 15 | 15 | | | | |
| *Lake Sequoyah* | 1999, 2004 | 18 | 27 | | | 15 % | 4 % |
| *Thorpe Reservoir* | 1995, 1999, 2004 | 12 | 28 | | | | |
| *Wolf Creek Reservoir* | 1996, 1999, 2001, 2004 | 10 | 20 | | | | |
| NEUSE RIVER BASIN | | | | | | | |
| *Apex Reservoir* | 1995, 2000 | 1 | 2 | | | | |
| *Buckhorn Reservoir* | 1995, 2005 | 4 | 4 | | | | |
| *Corporation Lake* | 1995, 2000 | 2 | 8 | | | | * |
| *Falls of the Neuse Reservoir* | 1995, 1997, 2000, 2001, 2005 | 90 | 214 | 7 % | 0.5 % | | 12 % |
| *Lake Ben Johnson* | 1995, 2002 | 1 | 4 | | | | |
| *Lake Benson* | 1995, 1996, 2000, 2005 | 2 | 14 | | | | 7 % |
| *Lake Butner* | 1995, 2000 | 2 | 6 | | | | |
| *Lake Michie* | 1995, 2000 | 2 | 8 | | | | |
| *Lake Orange* | 1995, 2000 | 1 | 9 | | | | |
| *Lake Rogers* | 1995, 2000 | 1 | 3 | | | | |
| *Lake Wheeler* | 1995, 2000 | 2 | 8 | | | | |
| *Lake Wilson* | 1995, 2000, 2005 | 1 | 5 | | | | |
| *Little River Reservoir* | 1995-1997, 2000 | 3 | 27 | | 4 % | | |
| *Toisnot Reservoir* | 1995, 2000 | 2 | 6 | | * | | |
| *Wiggins Mill Reservoir* | 1995, 2000, 2005 | 2 | 10 | | | 10 | |
| NEW RIVER | | | | | | | |
| *ASU Lake* | 1998, 2003 | 3 | 6 | | | | |

| Basin & Lake Name | Years Included in Analyses | # of Chl-a Samples | # of DO, ph & Turbidity Samples | Percentage of Samples Not Meeting Each Standard During January 1995 through May 2005 | | | |
|---|---|---|---|---|---|---|---|
| | | | | Chl-a | DO | pH | Turbidity |
| **ROANOKE RIVER** | | | | | | | |
| ***Belews Lake*** | 1999, 2000-2002, 2004 | *20* | *55* | | | | |
| ***Farmer Lake*** | 1999, 2000-2002, 2004 | *36* | *51* | | | | 6 % |
| ***Hyco Lake*** | 1999, 2004 | *12* | *24* | | | | |
| ***Kernersville Lake*** | 2000, 2004 | *3* | *11* | | | | |
| ***Lake Gaston*** | 1996, 1999, 2000, 2004 | *15* | *41* | | | | |
| ***Lake Roxboro*** | 1999, 2000-2002, 2004 | *18* | *42* | | | | 2 % |
| ***Mayo Reservoir*** | 1999, 2004 | *9* | *18* | | | | |
| ***Roanoke Rapids Lake*** | 1999, 2004 | *9* | *18* | | | | |
| ***Roxboro City Lake*** | 1999, 2004 | *18* | *30* | | | | |
| **TAR-PAMLICO RIVER** | | | | | | | |
| ***Lake Devin*** | 1997,2002 | *6* | *12* | | | | |
| ***Tar River Reservoir*** | 1997, 2002 | *12* | *24* | 8 % | | | 8 % |
| **YADKIN-PEE DEE RIVER** | | | | | | | |
| ***Back Creek Lake*** | 1999, 2001, 2002 | *15* | *21* | | | 5 % | |
| ***Badin Lake*** | 1999, 2002 | *48* | *63* | 2 % | 2 % | 8 % | |
| ***Blewett Falls*** | 1999 | *2* | *3* | | | * | |
| ***Bunch Lake*** | 1999, 2000, 2001 | *2* | *8* | | | | |
| ***High Rock Lake*** | 1997, 1999, 2000-2005 | *2* | *160* | 28 % | | 12 % | 13 % |
| ***Kannapolis Lake*** | 1995, 2000 | *2* | *8* | | | | |
| ***Kerr Scott Reservoir*** | 1999, 2000-2002 | *9* | *33* | | | | |
| ***Lake Concord*** | 1995, 2000 | *3* | *9* | | | | |
| ***Lake Corriher*** | 1999 | *0* | *6* | | | | |
| ***Lake Fisher*** | 1995, 2000 | *3* | *12* | | | | 8 % |
| ***Lake Lee*** | 1995, 2000 | *3* | *12* | | | 18 % | |
| ***Lake Monroe*** | 1995, 2000 | *2* | *8* | | | * | |
| ***Lake Reese*** | 1995, 2000-2002 | *15* | *33* | | | | |
| ***Lake Thom-A-Lex*** | 1999, 2000-2002 | *6* | *16* | | | | 8 % |
| ***Lake Tillery*** | 1999 | *0* | *12* | | | | |
| ***Lake Twitty (Lake Stewart)*** | 1995, 2000 | *3* | *12* | | | 58 % | |
| ***Lake Wright*** | 1999 | *0* | *4* | | | * | |
| ***McCrary Lake*** | 1999- 2001 | *2* | *8* | | | * | |
| ***Roberdel Lake*** | 1995, 2000 | *2* | *6* | | | * | |
| ***Rockingham City Lake*** | 1995, 2000 | *1* | *3* | | * | * | |
| ***Salem Lake*** | 1999-2002 | *9* | *33* | | 3 % | | |

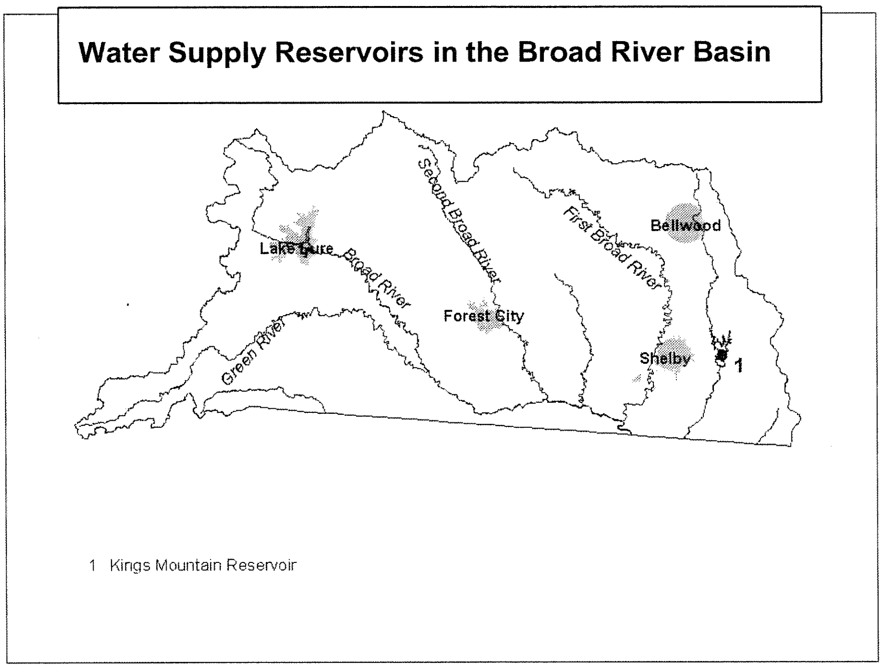
| Basin & Lake Name | Years Included in Analyses | # of Chl-a Samples | # of DO, ph & Turbidity Samples | Percentage of Samples Not Meeting Each Standard During January 1995 through May 2005 | | | |
|---|---|---|---|---|---|---|---|
| | | | | Chl-a | DO | pH | Turbidity |
| ***Tuckertown Reservoir*** | 1999 | *0* | *6* | | | | |
| ***Wadesboro City Pond*** | 1995, 2000 | *2* | *7* | | | | |
| ***Water Lake*** | 1995, 2000 | *2* | *6* | | | * | |

* Less than 10 samples but one or more exceeded the standard.

# Appendix 2. Water Supply Reservoir Water Quality For Selected Water Supplies By Basin

These discussions include water supply reservoirs that have water quality concerns but that may not be exceeding any standards more than 10 percent of the time.

## Broad River Basin




### Basin Overview

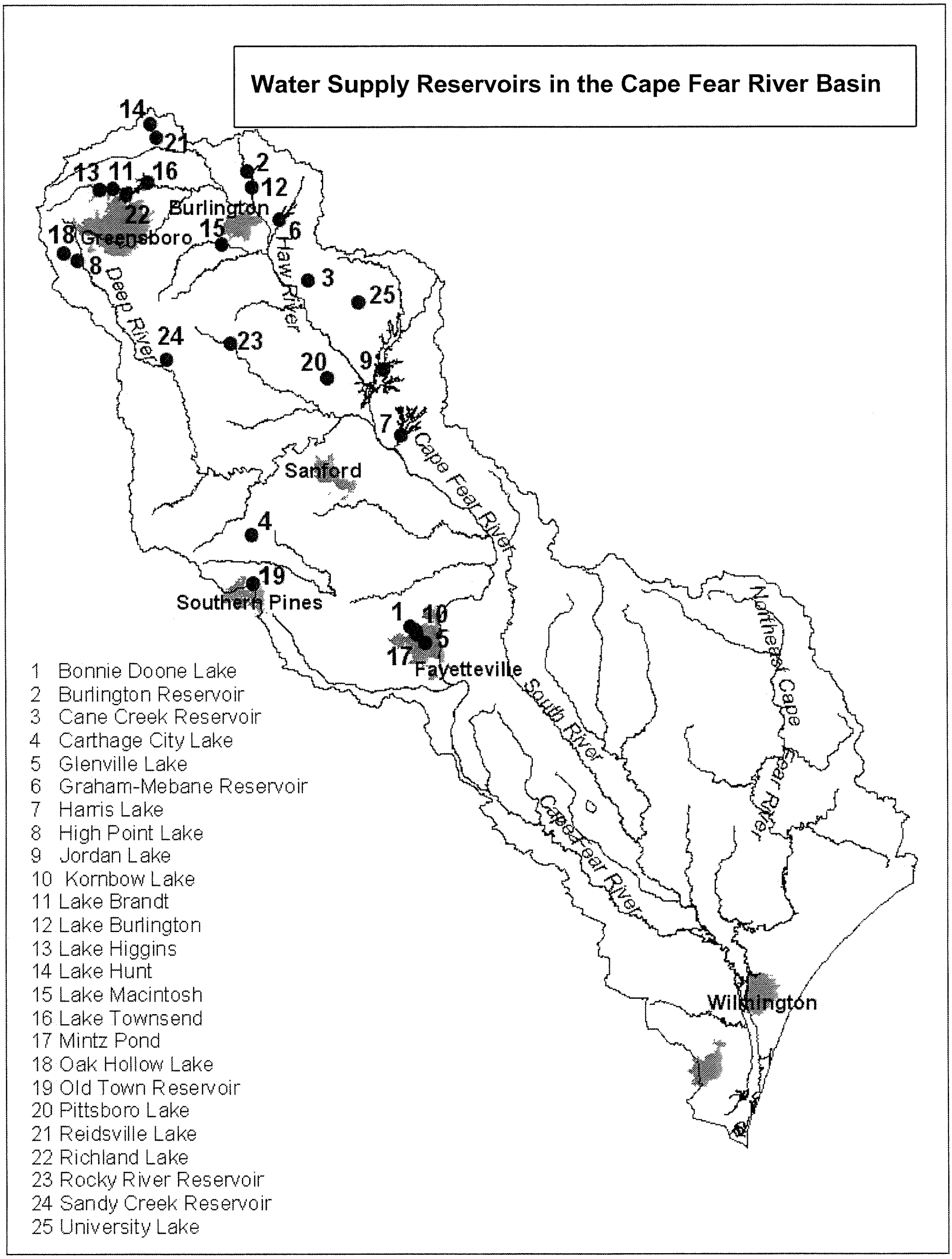
The Broad River Basin encompasses a 1,506 square mile watershed drained by 1,452 miles of streams. The three major tributaries to the Broad River are the Green, Second Broad and First Broad Rivers. Flowing from the Blue Ridge Mountains, the Broad River moves through the foothills before entering the piedmont southeast and east of Lake Lure. From there, the Broad flows through Rutherford and Cleveland counties then into South Carolina. The basin encompasses most of Cleveland, Polk and Rutherford counties and portions of Buncombe, Henderson, Lincoln and Gaston counties. Larger municipalities include Forest City, Kings Mountain, Lake Lure, Rutherfordton, Shelby and Spindale.

### Kings Mountain Reservoir

Only one of the lakes sampled by DWQ in the Broad River Basin is classified as WS. That is Kings Mountain Reservoir. Kings Mountain Reservoir (also known as Moss Lake) is a water supply for the Cities of Kings Mountain and Grover. The reservoir was constructed in 1963. Major tributaries to the lake include Buffalo Creek and Whiteoak Creek. The drainage area is characterized by rolling hills and rural areas. Access to the lake is strictly controlled to allow recreational use while protecting water quality.

Two samples taken in 1992 exceeded the pH standard. Both samples were 9.2 standard units (SU). All the other 64 samples taken between 1989 and 2005 met the standards.

# Cape Fear River Basin



## Basin Overview

The Cape Fear River Basin is the largest river basin in the state, covering 9,149 square miles in 24 counties. There are an estimated 6,300 miles of streams and rivers in the basin confined to the Piedmont and Coastal Plain. These areas are further subdivided into Southern Outer Piedmont, Northern Inner and Outer Piedmont, Carolina Slate Belt, and Triassic Basin in the Piedmont. The Coastal Plain contains the Sand Hills, Rolling Coastal Plain, Carolina Flatwoods, and the Southeast and Mid-Atlantic Floodplains and Low Terraces subecoregions. The Cape Fear River is formed by the confluence of the Deep and Haw Rivers at the Chatham/Lee County line. B. Everett Jordan Reservoir is the largest impoundment in the basin. Several large tributaries join the river as it flows towards the Atlantic Ocean near Southport: Upper and (Lower) Little Rivers, Rockfish Creek, Black River, South River and the Northeast Cape Fear River.

Highly urban and industrialized areas around the cities of Greensboro, High Point, Burlington, Chapel Hill, and Durham in the upper part of the watershed and around Fayetteville and Wilmington in the middle and lower part characterize the basin. Fort Bragg Military Reservation occupies a large area in the middle of the basin.

The Division of Water Quality sampled 24 lakes classified as WS between 1981 and May 2005. Of these 4 exceeded water quality standards in more than 10 percent of the samples taken: Graham-Mebane Reservoir, High Point Lake, Jordan Lake, and Lake Mackintosh.

Pittsboro Lake is not discussed below, as it does not have a water supply intake; however, it is on the Impaired Waters list due to aquatic weeds and has some exceedances of the chlorophyll a, pH, turbidity and manganese standards.

Old Town Reservoir, which is no longer used as a water supply, is also not discussed below. The 13 samples that did not meet the pH standard were all below 6.0 SU and were due to natural inflows. Mill Creek, a black water creek with excellent water quality, feeds into Old Town Reservoir and reduces pH readings in the upper end of the reservoir.

## Lakes with Water Quality Concerns

### Graham-Mebane Reservoir

This reservoir serves the water supply needs for the Towns of Graham, Mebane, Green Level and Haw River. The reservoir is 11 years old and is an impoundment of Quaker and Back Creeks, encompassing the old Quaker Creek Reservoir. The immediate shoreline is primarily forested except for a few houses, a school, and some farmland.

The reservoir was most recently sampled in 2003. As had been observed in previous years, Secchi depths in 2003 were consistently less than one meter and the turbidity standard was exceeded twice. The turbidity standard was also exceeded once in 1998. The water was brown from suspended sediments. Nitrogen concentrations (nitrate/nitrite) were approximately three times those previously measured and generally ranged from moderate to elevated (0.62 to 0.79 mg/L). Total phosphorus concentrations were slightly elevated (0.04 to 0.05 mg/L).

These nutrients may have supported an increase in algal growth as indicated by chlorophyll-a concentrations. In July and August, chlorophyll-a concentrations exceeded the water quality standard of 40 µg/L five times (48 to 67 ug/L). These elevated concentrations were attributed to algal blooms consisting of *Gonyostomum* sp. This taxon is indicative of eutrophic conditions and can form nuisance blooms in the summer[1].

The increase in chlorophyll-a and turbidity is a concern in this water supply and warrants additional attention. Additional sampling is planned for this lake as resources allow.

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[1] Wehr, J. D. and R. G. Sheath (eds.). 2003. Freshwater algae of North America: ecology and classification. Academic Press, San Diego, CA.

## High Point Lake

High Point Lake (also known as City Lake) is used for water supply and recreation. Urban/residential areas and pasture/row crop farms dominate the watershed. The two arms of the lake are fed by the East Fork Deep River and the West Fork Deep River.

DWQ sampling found four exceedances of the chlorophyll-a standard and three exceedances of the manganese standard. However, the City of High Point has a more extensive monitoring program and has documented numerous complaints regarding taste and odor related back to algal blooms in High Point Lake. They also have documented elevated pesticides.

To reduce this problem, the water treatment plant currently treats the raw water to reduce algae-related taste and odor problems. They have also installed a forced air destratification system in the lake to increase mixing and address dissolved oxygen concerns. In addition to summer algal blooms, the City documented a winter bloom that it attributed to the use of fertilizer as a deicer during a winter ice storm.

Water clarity has decreased since 1984. This reduction in clarity has been associated with algal blooms and two highway construction projects (one for I-40 and the other for Hwy 73/74 Bypass). *Lyngbya wollei*, a filamentous blue green alga that forms thick mats, which clog water intakes and foul boat motors, has been the dominant species in this lake.

In the 2005 Cape Fear River Basinwide Water Quality Report, High Point Lake was declared Impaired for aquatic life because 3 out of 12 chlorophyll-a samples exceeded the water quality standard during 2003. That report recommends that High Point and Greensboro use their respective stormwater programs to address water quality problems, including reductions in the nutrient loading that is driving the algal blooms in High Point Lake.

High Point Lake will be added to the 303(d) list.

## B.E. Jordan Reservoir

B. Everett Jordan Reservoir (Jordan Lake) is located in Chatham County in the eastern piedmont of North Carolina. The United States Army Corps of Engineers created the lake for various purposes including flood control, fish and wildlife habitat, recreation, and water supply. The dam was completed in 1974; however, initial filling of the lake did not occur until late 1981 as a result of legal and construction problems.

Major inflows into Jordan Lake are the Haw River and New Hope and Morgan Creeks. The Haw River has an average hydraulic retention time of five days and accounts for 70-90 percent of the annual flow through Jordan Lake. The New Hope arm of the lake has an average hydraulic retention time of 418 days. The Jordan Lake watershed encompasses 1,686 square miles and includes parts of Alamance, Caswell, Chatham, Durham, Forsyth, Guilford, Orange, Randolph, Rockingham and Wake counties. It includes all or portions of the urban areas of Durham, Chapel Hill, Cary, Burlington, Greensboro and several other small municipalities.

In 1983, Jordan Lake was classified as NSW based on water quality sampling showing increasing nutrient loading and documenting algal blooms and other biological impacts. As a result of the classification, a plan to reduce nutrient inputs was developed that required total phosphorus limits of 2.0 mg/L for NPDES permitted wastewater facilities with permitted flows greater than 0.005 MGD[2]. Due to special concerns for the Upper New Hope Arm of the reservoir, NPDES facilities received TP limits of 0.5 mg/L during the months of April to October (algal growing season).

Algal blooms have been documented by DWQ from August 1982 through May 2005 with 311 exceedances of the chlorophyll-a standard out of 1015 samples (31 percent). During 2003 in June, July and August, 38 percent of the chlorophyll-a samples taken by DWQ were above 40 ug/L. During 2005 between January and mid-April, 44 percent of the samples were above 40 ug/L.

Blooms of blue-green algae associated with taste and odor problems in drinking water

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[2] DENR. 2005. 2005 Cape Fear River Basinwide Water Quality Plan. http://h2o.enr.state.nc.us/basinwide/index.htm

were observed in July 2003. As part of special monitoring in 2005, algal samples were analyzed monthly. Jordan experienced moderate to severe algal blooms (densities between 20,000 to 49,500 units/ml) during January and throughout the summer. Chlorophyll-a concentrations in January exceeded the standard twice (43 & 46 ug/L). The dominant species by density during January was a filamentous blue green alga (*Planktothrix sp.*). Chlorophyll-a concentrations also exceeded the standard during February, March and April.

Measurements of pH (another indicator of algal activity) were elevated at times with 64 samples above the pH standard of 9.0 SU. Other parameters that exceeded water quality standards included dissolved oxygen, turbidity and manganese.

Jordan Lake was listed as Impaired in 2002 for chlorophyll-a and a draft TMDL has been developed for EPA approval. That process involved a formal stakeholder process, which included a total of 21 stakeholder meetings between May 2003 and December 2004. An implementation plan is being developed with the Jordan Stakeholders' participation[3].

DWQ and the EMC will continue to work with the stakeholders to develop an implementation plan. Additional monitoring is planned for Jordan Lake over the next 4 years to assist in developing a baseline to compare with water quality after control actions are in place.

### Lake Mackintosh

Lake Mackintosh, an impoundment of Big Alamance Creek, is a 10-year-old water supply reservoir for the City of Burlington. The lake is used for secondary recreation – only electric trolling motors are allowed or paddle boats, no swimming. The surrounding land is comprised of pastures and farmland with a few houses. The reservoir has been sampled 12 times by DWQ.

This lake has experienced algal blooms since its creation and the dominant algal species has been blue-green alga associated with taste and odor problems. In addition to regular ambient lakes monitoring, DWQ has done additional sampling at the request of the City of Burlington due to taste and odor problems at the Water Treatment Plant. The dominant species at those times was a small filamentous blue green alga, *Aphanizomena flos-aquae*. No reports of taste and odor problems have been received since 1997 even though algal populations were elevated in 2003 as shown by chlorophyll-a and biovolume estimates. Chlorophyll-a concentrations ranged from 12 to 65 ug/L and biovolume in samples analyzed by DWQ ranged from 4,000 to 31,000 units/ml. DWQ considers a bloom to be present if concentrations are above 10,000 units/ml. The species present in 2003 was *Lyngbya sp.*, a common planktonic blue green that can be found in reservoirs throughout North Carolina. This species has also been known to cause taste and odor problems.

Algal blooms are to be expected in the first years of a reservoir's life as the organic materials that were there during filling decay and release nutrients. According to Stephen Shoaf, City of Burlington Director of Utilities, the reservoir has settled down and the City continues to monitor alga in the reservoir. DWQ data indicate that highest nutrients are found in the Big and Little Alamance Creek Arms of the lake.

In addition to elevated algal populations, the lake has about two acres of creeping waterprimrose, a nuisance aquatic weed whose scientific name is *Lugwigia hexapetala*. The lake was treated in 2004 and 2005 by herbicides to address the problem.

### Bonnie Doone Lake

Bonnie Doone Lake is located in close proximity to Fort Bragg Military Base. Firebreaks located on the base and the sandy soil contribute large amounts of sediment into the lakes through stormwater runoff. The surrounding shoreline of Bonnie Doone is forested; however, development is increasing in the watershed. The western side of the lake beyond the forested buffer is urbanized. The City of Fayetteville controls access to this water supply and monitors the

[3] More information on that process is available at http://h2o.enr.state.nc.us/tmdl/.

lake on a regular basis. Their monitoring program is more comprehensive than DWQ's, sampling more frequently and analyzing for more parameters. They are proactive in identifying sources and instituting controls.

All three samples in 2003 had low pH values. The City of Fayetteville has also noted low pHs and believes that they may be attributed to the soft water interfering with pH and conductivity readings[4]. This region has sandy soils and tannic streams. All other standards were met. Programs such as the City of Fayetteville's are to be encouraged and supported as they provide more frequent assessments of water quality and quicker response to problems.

## Lake Cammack

Lake Cammack, also called Burlington Reservoir, is a water supply storage reservoir for the City of Burlington located upstream of Stoney Creek Reservoir, the City's primary water supply source. Lake Cammack is located at the confluence of Stoney and Toms Creeks in Alamance County. The immediate watershed area consists primarily of forested and agricultural land, although there is some development beginning in the watershed.

The reservoir was most recently monitored in 2003. In response to the availability of nutrients, algae growth increased as evidenced by elevated chlorophyll-a concentrations. Chlorophyll-a concentrations in the upper end of the lake during June and August (45 and 52 µg/L, respectively) were greater than the water quality standard of 40 µg/L. *Chrysochromulina* sp. dominated the June algal bloom. In August, the bloom was of the filamentous blue green *Anabaenopsis raciborskii*. These taxa are known to cause taste and odor problems in drinking water supplies.

There were the only two chlorophyll-a samples out of 14 (7 percent) above the standard. The City of Burlington has treated Lake Cammack to control *Lyngbya wollei*, a filamentous blue green that forms wooly mats[5].

Manganese concentrations exceeded the WS standard in one sample out of 14 samples taken between 1981 and 2005. No instances of taste and odor problems have been reported to DWQ.

## Stoney Creek Reservoir

Stoney Creek Reservoir, an impoundment of Stony Creek downstream of Lake Cammack, is the primary water supply reservoir for the City of Burlington. This reservoir is also known as Lake Burlington. The immediate watershed is characterized by rolling hills and agriculture is the most common land use.

The reservoir was most recently monitored in 2003. The water was brown from suspended sediments and exceeded the turbidity standard twice. Total phosphorus concentrations in July and August 2003 were greater than those previously observed. During the summer, nitrogen concentrations were also greater than those values previously observed. Despite the availability of these nutrients, 2003 chlorophyll-a concentrations were not greater than the water quality standard of 40 µg/L (probably due to shading from the suspended sediments). However, chlorophyll-a concentrations were above the standard in July 1990 at both stations.

There are no NPDES permitted facilities in these watersheds; agricultural nonpoint sources of pollution and habitat degradation (severe bank erosion and sandy, embedded substrate) are currently the main concerns. The 2005 Cape Fear River Basinwide Water Quality Plan[6] noted problems in the watershed related to drought conditions and habitat degradation from land disturbing activities.

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[4] Sidney Post, Fayetteville Public Works Commission; personal communication December 28, 2005

[5] Stephen Shoaf, Utilities Director for the City of Burlington; personal communication December 29, 2005

[6] DENR. 2005. 2005 Cape Fear River Basinwide Water Quality Plan. http://h2o.enr.state.nc.us/basinwide/index.htm

### Mintz Pond

The immediate shoreline of Mintz Pond is forested but the lake is surrounded by urban development. The impoundment is shallow with a maximum depth of only five feet at the dam.

In 2003, large areas of water lilies (*Nymphaea odorata*) were observed along the shoreline and upper end of the lake. Water lilies have been observed along the lake shoreline since 1998 but are not at nuisance levels. Smaller beds of watershield, *Brasenia schreberi,* were also observed. Variable-leaf watermilfoil is found throughout the lake. The macroscopic alga, *Nitella* sp., grows on the lake's bottom; it is an indicator of clear water.

The single exceedance of the turbidity standard was from the 1993 sampling period. Since then turbidities have ranged from 3.1 to 15 mg/L, well below the lake turbidity standard for 25 mg/L.

As with Bonnie Doone, pH measurements were below the standard. The City of Fayetteville attributes this to the softness of the water and continues to do additional research to determine how best to sample these waters. Tannic inflows may contribute to the low pH measurements found in this lake.

The City's monitoring program measures water quality more frequently and monitors for more parameters than DWQ. They actively pursue source identification and control.

### Cane Creek Reservoir

Cane Creek Reservoir was built in 1989 by Orange Water and Sewer Authority (OWASA) to serve as a water supply reservoir for the Town of Chapel Hill. A majority of the 20,262-acre watershed is forested with some agriculture. Since 1997, OWASA has been acquiring acreage in the watershed to help protect the watershed. As of 2003 they had received approximately $1.75 million to purchase 1,559 acres plus 467 acres in conservation easements. The Haw River Assembly has also received a mini-grant of $25,000 to purchase six tracts along Cane Creek and the Haw River.

DWQ has sampled the reservoir 11 times since 1990. In 2003 concentrations of nutrients ranged from moderate to elevated and chlorophyll-a concentrations were elevated during summer sampling. Blue green algal blooms also occurred throughout the summer. Chlorophyll-a concentrations were measured up to 170 ug/L, which is over four times the water quality standard of 40 ug/L. The pH measurements exceeded the standard in 1996 and may have been indicative of algal blooms.

The 2005 Cape Fear River Basinwide Water Quality Report recommends working with the Division of Soil and Water Conservation (DSWC) to address agricultural nutrient sources and to add additional sampling as part of the Ambient Lakes Program. OWASA is continuing to work on local awareness and controls.

### Lake Brandt

Lake Brandt is one of three primary water supplies for Greensboro, the third largest city in North Carolina. The lake covers approximately 410 acres and has a drainage area of approximately 40.2 square miles. The shoreline of Lake Brandt is forested and the watershed contains of a mix of residential developments, pastures, row crop fields and scattered small businesses.

Of the samples taken since 1981, three out of 30 chlorophyll-a samples were above 40 ug/L. Those samples were taken in 1982 and 1993. None of the nine samples taken in 2003 were above the standard.

Other parameters that were above state standards were pH in 1981, turbidity (1 sample in 2003) and manganese (1 sample in 1988).

The turbidity sample of 2003 was not associated with any elevated chlorophyll-a but was from the shallowest station (4 feet) and could represent bottom disturbance.

### Lake Hunt

Lake Hunt has been sampled by DWQ since 1981. The lake is now used for recreational purposes, but served as the Town of Reidsville's primary water supply until 1979, when Reidsville Lake was built. Lake Hunt is on an unnamed tributary to Troublesome

Creek. The boat launch area is privately owned and public access is restricted. Land use was primarily agricultural although residential development is occurring upstream.

Data collected in 2003 indicated elevated dissolved oxygen and chlorophyll-a concentrations. Nutrient concentrations ranged from moderate to elevated. These characteristics indicated increased algal productivity and resulted in the lake being classified as eutrophic (over-enriched with nutrients). In previous years, the lake had been classified as mesotrophic or oligotrophic (moderate and low nutrient enriched).

Elevated pH measurements (above standard of 9.0 SU) were recorded in 1981. No other elevated pHs have been reported since that year.

The 2005 Cape Fear River Basinwide Water Quality Report notes that there are water quality issues in the Troublesome Creek watershed and states that DWQ will work with the Division of Soil and Water Conservation staff to further implement best management practices (BMPs) to reduce the impacts of agriculture in the watershed. In addition, acquisition of 500 acres along the Haw River and Troublesome Creek by the Piedmont Land Conservancy may provide additional protection to this portion of the watershed.

### Lake Reidsville

Lake Reidsville (also called Reidsville Lake) is a water supply reservoir located on Troublesome Creek just outside of, and owned by, the City of Reidsville. The topography of the immediate watershed is characterized by rolling hills and land use is mainly row crop and pastures along with residential and commercial development. Rockingham County limits activities in the watershed with strict zoning laws; the reservoir has a 100-foot buffer with a 50-foot buffer on all tributary streams. A city park with a boat launch area is located off of SR 2435.

Chlorophyll-a concentrations exceeded the standard in four out of six samples in 2003 and were more than twice the concentrations recorded in 1988 and 1993. One turbidity sample taken in 2003 was above the lake standard of 25 NTU (34 NTU).

Hydrilla *(Hydrilla verticillata)*, an invasive non-native aquatic weed, is present in Lake Reidsville and, in 2004, the City of Reidsville planned to treat 400 acres of the lake by stocking it with 6,000 grass carp with matching funding from the Division of Water Resources. This treatment did not occur and, per Mr. Steve Routh, the City of Reidsville is considering other control options[7]. The City is considering cold weather drawdown to freeze the Hydrilla out and is in discussion with the City of Greensboro to utilize their equipment and expertise for chemical control.

Mr. Routh noted that water quality in Lake Reidsville was very good and that they had not seen any blooms. Based on this information, it is recommended that no action be taken regarding use support determinations until additional sampling can be conducted to verify the 2003 data. DWQ staff will also work with DSWC staff to implement additional BMPs in the watershed.

### Oak Hollow Lake

This reservoir, an impoundment of the West Fork Deep River, is commonly used for recreational activities. It has a maximum depth of 36 feet. The watershed is characterized by urban, residential, and some agricultural land uses; two 18-hole golf courses are along the shoreline. The reservoir has been sampled 23 times by DWQ since 1981.

Only turbidity and manganese measurements exceeded state standards. One turbidity sample of 26 NTU was recorded in July of 1997 and two manganese samples of 210 and 250 ug/L were recorded in August 2003 and July 2000.

Due to problems with anoxia (dissolved oxygen concentrations near or at 0 mg/L) in the water column, the City of High Point installed a destratification system. No

[7] Steve Routh, City of Reidsville Public Works; personal communication December 29, 2005

surface dissolved oxygen measurements were below standards in DWQ sampling; however, during stratification the lake did exhibit low dissolved oxygen up to around 9 feet (maximum depth is approximately 30 feet).

West Fork Deep River is rated as Impaired for Aquatic Life use support in the Draft 2005 Cape Fear River Basinwide Water Quality Report due to exceedances of the fecal coliform bacteria and turbidity standards. Actions taken to address these problems will also provide protection for Oak Hollow and should provide some nutrient loading reductions as a by-product.

Additional sampling will be conducted at the reservoir to allow a full use support assessment as resources become available.

### Pittsboro Lake

Pittsboro Lake is a small impoundment of Robeson Creek (Figure 32). The reservoir was originally a system of two separate ponds connected by a canal. Hurricane Floyd in September 1999 destroyed the canal, resulting in the formation of a single, shallow waterbody. The maximum depth is seven feet. The drainage area is composed of forested, urban, and agricultural areas. This lake has been sampled seven times by DWQ.

The reservoir was most recently monitored in 2003. It was classified as eutrophic throughout the period. Mild to severe algal blooms occurred throughout the summer sampling period. The blooms were dominated by *Chrysochromulina* sp., an indicator of eutrophic conditions and which can cause taste and odor problems in drinking water supplies (Wehr and Sheath 2003). No blooms occurred at the other station due to the large amounts of aquatic macrophytes and less open water found at the site.

Parrot feather, *Myriophyllum aquaticum*, has been found in the reservoir. The submerged macrophyte is highly invasive and forms dense growths providing excellent habitat for mosquitoes. It is difficult to eradicate and is inedible to Grass carp. Excessive macrophyte growths were also noted in 1998. This reservoir is on the 303(d) list of impaired surface waters because of the excessive growths of aquatic weeds.

In 2000, the Town of Pittsboro (owners of the dam) had considered breaching the dam and restoring Robeson Creek and its riparian buffer back to their natural conditions. This restoration project has been delayed pending improvement of the local economy.

### Rocky River Reservoir

The Rocky River Reservoir, a water supply reservoir for Siler City, is an impoundment of the Rocky River high in its watershed. The reservoir was most recently sampled in 2003. This reservoir demonstrated excessive nutrient enrichment and very high levels of biological productivity.

Frequent rainfall events during the summer of 2003 may have increased the amount of nonpoint source runoff from the rural watershed to the reservoir and increased the nutrient loading. The watershed is primarily agricultural with some pasture immediately adjacent to the lake. Cattle and horses have direct access to the upper end of this reservoir. Pastureland for these animals slopes downhill to the water's edge. This provides one source of nonpoint nutrient contributions to the reservoir.

Water clarity was consistently poor throughout 2003, and water quality standards were exceeded for chlorophyll-a. During a special study in 2002, nutrients and conductivity values were found to be elevated upstream of the reservoir in the Rocky River and the North Prong Rocky River as well.[8]

This reservoir, an impoundment of the Rocky River, serves as a water supply for Siler City. The impoundment was expanded in 1988 to raise the existing storage capacity from 60 million gallons to 424 million gallons. The expansion raised the water level by approximately 10 feet. Another expansion is planned for 2006.

In order to expand the reservoir a portion of the Rocky River below the current dam had to be reclassified to WS-III CA. Additional

[8] DWQ. 2002. Internal Data Review.

monitoring and watershed controls were required as part of the reclassification and 401 Water Quality Certification & Isolated Wetland Permit process. These requirements include addressing problems related to agriculture in the watershed. Siler City is currently participating with DWQ and other stakeholders in developing monitoring strategies for the lower river and is planning to assist with a workshop on determining current activities related to water quality in the entire Rocky River watershed.

DWQ intends to continue working with the local stakeholders on addressing nutrient loading to the watershed.

### Lake Ramseur

Lake Ramseur, a raw source of water for the Town of Ramseur, is located northwest of the city in Kermit Pell Park on Sandy Creek. Also known as Sandy Creek Reservoir, the lake covers 125 acres. The lake is formed by the impoundment of Big Sandy and Little Sandy Creeks. The maximum depth is 48 feet. The immediate watershed is moderately developed. Major land uses are forestry and agriculture. The reservoir has been sampled eight times by DWQ since 1992.

The reservoir was most recently sampled in 2003. Nutrient concentrations were elevated and supported increased algal productivity as indicated by the elevated chlorophyll-a concentrations. During the summer chlorophyll-a concentrations were greater than the water quality standard of 40 µg/L. Algal blooms, composed primarily of diatoms and blue greens, occurred throughout the summer. The blooms were most prevalent near the dam. The algal species found are associated with taste and odor problems in drinking water supplies. DWQ has not received any complaints regarding taste and odor in the lake.

In 1997, the Piedmont Land Conservancy received a $134,000 Clean Water Management Trust Fund (CWMTF) grant to acquire 144 acres of permanent easements in this watershed.

### University Lake

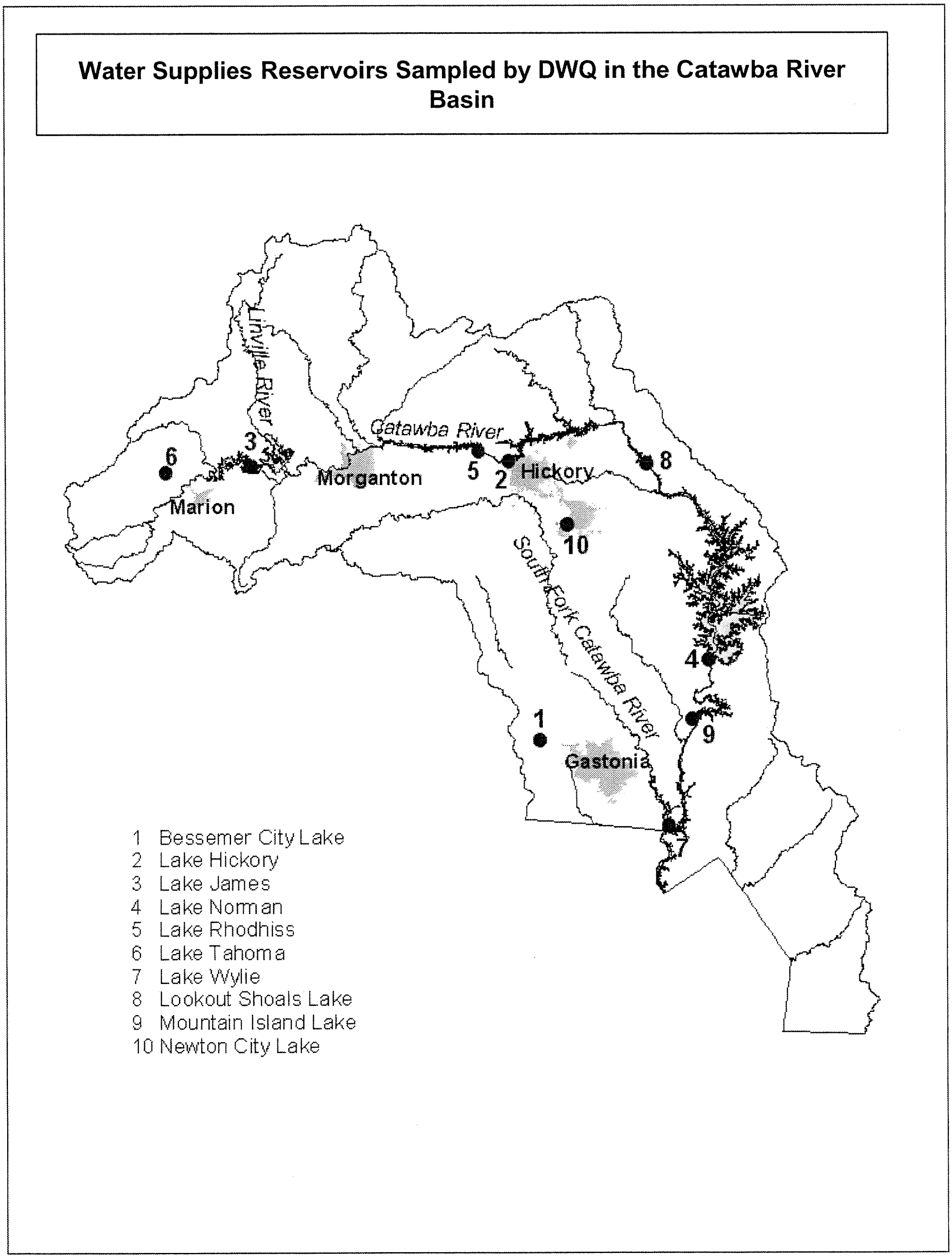
University Lake was built in 1932 by UNC Chapel Hill. University Lake holds 450 million gallons of water. Its tributaries include Morgan Creek, Phils Creek, Neville Creek, Price Creek and Pritchards Mill Creek. The lake has a 213-acre surface area. Carrboro and Chapel Hill use University Lake as a drinking water source.

The reservoir was most recently sampled in 2003. Nutrient concentrations were elevated and supported increased algal productivity as indicated by the elevated chlorophyll-a concentrations. During the summer five chlorophyll-a concentrations (58, 99, 160, 73, & 62 ug/L) were greater than the water quality standard of 40 µg/L. Algal blooms, composed primarily of diatoms and blue greens, also occurred throughout the summer. The blooms were most prevalent near the dam. *Chrysochromulina breviturrita*, *Lyngbya* sp. and *Aphanizomenon flos-aquae*, blue-green algae, were the dominant summer species and are known to cause taste and odor problems in drinking water supplies.

In August 2005, public complaints were received regarding the water in University Lake being red in color and an investigation found that a *Euglena* bloom was occurring. The species present turned bright red in the sunlight and covered much of the lake's surface (Ed Holland, Orange Water and Sewer Authority (OWASA); email August 25, 2005). Rainfall early the next morning dispersed the bloom. Euglenids are known for being very mobile and dispersing quickly. No taste and odor problems nor treatment issues were noted by OWASA. The only water quality parameter that was elevated at this time period was ammonia in the lower water column. This potentially could be the trigger as Euglenids thrive on elevated ammonia concentrations.

The city has done much to protect the University Lake watershed and continues to identify and eliminate pollution sources. It is recommended that such proactive management continue.

# Catawba River Basin




## Basin Overview

The Catawba River basin, along with the Broad River basin, forms the headwaters of the Santee-Cooper River system, which flows through South Carolina to the Atlantic Ocean. The basin is the eighth largest river basin in the state covering 3,279 square miles in the south central portion of western North Carolina. The Catawba River has its source on the eastern slopes of the Blue Ridge Mountains near the Town of Old Fort in McDowell County, and flows eastward, then southward, to the state line near Charlotte. The basin encompasses all or part of 12 counties: Alexander, Avery, Burke, Caldwell, Catawba, Gaston, Iredell, Lincoln, McDowell, Mecklenburg, Union, and Watauga. Large urban areas include Belmont, Charlotte, Conover, Gastonia, Hickory, Lenoir, Lincolnton, Mooresville, Morganton, Mt. Holly, and Newton.

Once out of the mountains, the flow of the Catawba River is regulated by a series of hydroelectric dams. These dams form the Catawba Chain Lakes: Lake James, Lake Rhodhiss, Lake Hickory, Lookout Shoals, Lake Norman, Mountain Island Lake and Lake Wylie. All of these lakes are classified as WS-IV in all or portions of their waters. In addition to the chain lakes, Lake Tahoma, Newton City Lake and Bessemer City Lake carry WS classifications and were reviewed for water quality standard exceedances.

Lakes in the Catawba River Basin that met water quality standards were: Lake James, Mountain Island Lake, Newton City Lake, Lake Norman and Bessemer City Lake. Lake Tahoma, although it carries the WS-II classification, is not currently used for water supply and had only one pH value that was below the standard.

One of the largest problems facing water users in this basin is nuisance growths of aquatic weeds. All of the chain lakes have some species of noxious weed that requires control. Hydrilla has been found in Mountain Island Lake, Lake James and Lake Norman. Parrotfeather, *Myriphyllum aquaticum,* has infested the upper ends of Lake Hickory and Lookout Shoals Lake. This situation is becoming more prevalent and the Division of Water Resources is working to assist citizens throughout the state in controlling noxious weeds.

Water quality in the other lakes is discussed in the following paragraphs. This discussion is organized such that Lake Rhodhiss, Lake Hickory and Lookout Shoals are reviewed first due to their interdependence. That review is followed by a discussion of Lake Wylie.

## Lakes with Water Quality Concerns

### Lake Rhodhiss

Lake Rhodhiss, which is owned by Duke Energy, is located between Lake James and Lake Hickory on the Catawba River. This is a run-of-the-river reservoir was built in 1925. It has 90 miles of shoreline, a surface area of approximately 3,060 acres and a mean hydraulic retention time of 21 days. Under the right temperature, light, and nutrient conditions, the longer retention times give algal populations an opportunity to bloom. The lake has been rated as eutrophic since the division began sampling it in 1981.

Beside hydroelectric power production the reservoir is used as a water supply and for public recreation. Granite Falls, Lenoir, Morganton and Valdese get their raw drinking water from Lake Rhodhiss.

Drought conditions that increased retention times and nuisance algae (especially blue-greens) blooms were recorded in 2001 and 2002. Public complaints of taste and odor problems in processed lake water resulted in a special study to investigate the extent and nature of the algal blooms. The study determined the existence of 15 well-established algal communities; five of which are known to cause taste and odor problems in processed drinking water.

During 2002, two out of 23 chlorophyll-a samples were above the state standard. It is not surprising that there were not more exceedances of the chlorophyll-a standard given the nature of the algal species present during that summer. Filamentous blue-green algae that have been linked with taste and odor problems were among the dominant species. These algae can regulate their location in the water column, tending to prefer the surface and as a result standard water column sampling may result in underestimation of their populations. These species also have smaller stores of chlorophyll-a than some of the other algal species and therefore must be in extremely high concentrations to exceed the chlorophyll-a standard. There were sufficient populations of these taste and odor producing algae to make it necessary for the water treatment plants to add activated charcoal to their treatment process.

In 2005 Lake Rhodhiss and Lake Hickory again experienced blue-green algal blooms and the Water Treatment Facilities received complaints of bad taste and odor.

Due to the proximity of the chain lakes, water quality in Lake Rhodhiss has a direct impact on Lake Hickory and, in turn, Lake Hickory impacts water quality in Lookout Shoals Lake. A synopsis of the recommendations for addressing Lake Rhodhiss eutrophication problems is provided following the review of water quality in Lake Hickory and Lookout Shoals.

### Lake Hickory

Lake Hickory is a run-of-the-river impoundment located between Lake Rhodhiss and Lookout Shoals Lake on the Catawba River. The lake is owned by Duke Energy and is used to generate hydroelectric power, for public water supply and recreational purposes. Hickory and Longview use Lake Hickory as a source of raw drinking water. The lake covers almost 4,223 acres with 105 miles of shoreline.

The water quality in Lake Hickory is driven by a variety of stressors including runoff from rural and urban areas, NPDES discharges, and perhaps most notably, the discharge from Lake Rhodhiss.

Lake Hickory has been sampled 22 by DWQ since 1984. This reservoir was consistently evaluated as eutrophic based on summer samples from 1984 to 1992. Since then, however, the reservoir has been more frequently evaluated as mesotrophic. High productivity was indicated in August 2002, but no visible algal blooms were observed.

In 2001, Duke Energy staff discovered Parrotfeather, *Myriophyllum aquaticum*, an invasive aquatic macrophyte, in the reservoir. Since 2001, the original 10-acre infestation has spread to 84 acres near the NC 321 bridge. Two drinking water intakes are located nearby and have the potential of becoming clogged by this plant. Businesses that rely on water-based recreation are also concerned because the infestation makes boating and swimming impossible where it is thickest. Duke Energy along with stakeholders and DWQ are working to develop and implement a Parrotfeather management program for the reservoir.

The Town of Hickory experienced taste and odor problems in their drinking water in 2002. Algal samples in May 2002 indicated the presence of filamentous blue-green algae (known taste and odor contributors) in Lake Hickory and Lake Rhodhiss. These problems persisted until algal populations died back in Lake Rhodhiss.

### Lookout Shoals Lake

Lookout Shoals Lake, situated directly below Lake Hickory and about 9 miles above Lake Norman, is one of the smaller Catawba River Chain Lakes. The watershed draining to the impoundment is relatively small, its largest tributary being the Lower Little River. The Lower Little River drains a predominately forest and agriculture area and carries a significant sediment load. Duke Energy owns the lake. Uses of Lookout Shoals include: generation of hydroelectric power, recreation, and public water supply. The lake's water quality is more reflective of releases from upstream impoundments (Lakes Hickory, Rhodhiss, and James) than conditions in the immediate watershed due to the short retention time.

Lookout Shoals Lake's main issue has been Parrotfeather. This noxious aquatic weed has taken over the entire lake and raises concerns that turbines at the hydro plants might be clogged if large mats break off. In 2002 the entire lake was drawn down in order to kill the Parrotfeather; however, rains prevented the draw down from being fully effective.

Currently, Duke Power is supporting an aquatic plant management research project in Lookout Shoals Reservoir in cooperation with NC State University, the NC Wildlife Resources Commission and the NC Wildlife Habitat Foundation[1]. This master's degree study is designed to determine the management impact of stocking sterile

[1] Kenneth L. Manuel, Aquatic Plan Management and Mosquito Control Program Leader, Duke Power Company. Personal communication January 23, 2006.

Asian grass carp in Lookout Shoals Reservoir for the control of Parrotfeather. A major component of the study assesses the impact of the grass carp stocking on the sport-fishery of the reservoir. The study includes the stocking of 9200 sterile grass carp lake-wide and the placing of eight "exclosures" to exclude the grass carp from selected Parrotfeather beds. Sterile Asian Grass Carp were stocked in Lookout Shoals Reservoir on May 25 and June 7, 2005. A total of 9200 grass carp were stocked in support of the project. Preliminary results should be available in late 2006 or early 2007.

### Management Recommendations for Lake Rhodhiss, Lake Hickory & Lookout Shoals

The close relationship between Lake Rhodhiss, Lake Hickory and Lookout Shoals Lake has led DWQ to conclude that a regional watershed management plan, encompassing both drainage areas, must be developed to address the water quality concerns in these reservoirs[2]. This planning effort must include cooperation and input from all stakeholders from the local to federal levels. Community-based efforts are already underway by Caldwell County, Burke County and others. For more information on these efforts see the Catawba River Basinwide Water Quality Plan[1]. DWQ plans to support and encourage these efforts, but recognizes that funding from a variety of sources must be made available to ensure long-term success of any planning and implementation.

Lake Rhodhiss is being added to the Impaired Waters List.

### Lake Wylie

Lake Wylie is the most downstream reservoir in the chain lakes. The reservoir was formed by the impoundment of the Catawba River in 1904 by a hydroelectric dam located near Fort Mills, SC. Duke Energy owns the lake. There are more than 327 miles of shoreline with the majority of the reservoir in South Carolina.

The immediate watershed of Lake Wylie is being converted from forested and agricultural areas to more urban land uses. This reservoir was eutrophic in 2001 and 2002. However, as a result of the City of Gastonia decommissioning its Catawba Creek WWTP and redirecting this effluent to the improved Long Creek WWTP, the Crowders Creek arm has shown an overall decrease in total phosphorus and total nitrogen. The City of Gastonia is the largest urbanized area located within the Crowders Creek watershed.

The reservoir was most recently monitored in 2001 and 2002. During both years, the reservoir was classified as eutrophic. The sampling site in the Crowders Creek Arm consistently had elevated surface dissolved oxygen and pH values in 2002. Crowders Creek is on the 303(d) list for biological impairment due to urban runoff and storm sewer contributions.

Lake Wylie and several of its major tributaries have experienced eutrophic conditions for decades. A joint study by DWQ and South Carolina Department of Environmental Control from April 1989 to September 1990 resulted in nutrient limitations for dischargers in an effort to reduce nutrient loading. Initially, minimum requirements were for a 5-day biochemical oxygen demand ($BOD_5$) of 15.0 mg/L, ammonia ($NH_3$) at 4.0 mg/L, and dissolved oxygen at 5.0 mg/L. Additional recommendations were made in 1995:

- Any new or expanding facility with a permitted design flow greater than or equal to 1.0 MGD must meet monthly average limits of 1.0 mg/L total phosphorus and 6.0 mg/L summer total nitrogen.
- For facilities with a permitted design flow of less than 1.0 MGD but greater than 0.05 MGD, a total phosphorus limit of 2.0 mg/L was recommended;
- Dischargers into Catawba Creek with a permitted design flow $\geq$ 0.05 MGD would have to meet a limit of

[2] DENR 2002. 2002 Catawba River Basinwide Water Quality Plan. http://h2o.enr.state.nc.us/basinwide/index.htm

0.5 mg/L total phosphorus and total nitrogen limits in the summer of 4.0 mg/L and 8.0 mg/L in the winter by January 1, 2006;

- Dischargers to Crowders Creek with a permitted discharge design of ≥ 1.0 MGD would have to reach a nutrient limit of 1.0 mg/L total phosphorus and 6.0 mg/L for total nitrogen in the summer by January 1, 2000.

The elevated percent dissolved oxygen saturation values in the reservoir coupled with elevated nutrient concentrations indicated that the best uses of Lake Wylie might be threatened by increasing biological productivity. Although 2001 and 2002 were drought years which limited nonpoint source runoff, the eutrophic conditions observed suggested that the lake may have sufficient nutrients coming into the lake from point sources as well as from internal cycling to maintain elevated biological productivity. Increasing urbanization of the watershed also threaten the best uses of this lake.

Since the 1995 recommendations, the City of Gastonia has decommissioned the Catawba Creek WWTP and redirected wastewater to the improved Long Creek WWTP. The Crowders Creek WWTP currently meets or is below the limits recommended in 1995

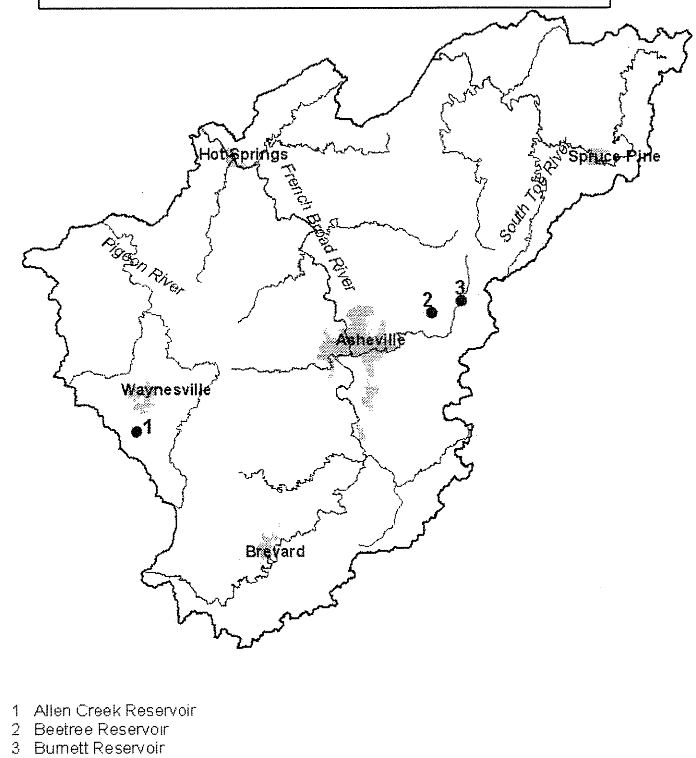
Lake Wylie is experiencing localized sedimentation problems in the Crowders Creek and Catawba Creek arms of the lake. DWQ, working with the local governments and South Carolina, continues to monitor progress in the lake and implementation of the management strategy.

# French Broad River Basin

## Basin Overview

The French Broad River basin covers 2,842 square miles with 4,113 miles of streams and is the ninth largest river basin in the state. It is located in the Blue Ridge Mountains and includes part or all of Transylvania, Buncombe, Henderson, Madison, Haywood, Yancey, Mitchell and Avery counties. All waters from the basin drain to the Gulf of Mexico *via* the Tennessee, Ohio, and Mississippi Rivers. Much of the basin lies within the 1.2 million acre Pisgah National Forest or Pisgah Game Lands. The northwest corner of Haywood County is in the Great Smoky Mountains National Park. Over one-half of the basin is forested. Steep slopes limit the area suitable for development and crop production. The basin is composed of three major drainages, the French Broad, Pigeon, and Nolichucky Rivers, which individually flow north into Tennessee.

**Water Supply Reservoirs Sampled by DWQ in the French Broad River Basin**




Allen Creek Reservoir and Burnett Reservoir were sampled in the French Broad River basin. Beetree Reservoir has not been sampled since 1997. No exceedances of any standard were recorded in these waters. These reservoirs are located in protected catchments and are strongly oligotrophic (low in nutrients) as are most mountain reservoirs. All three lakes are classified as WS-I and as such are also HQW.

The main threat to lakes in the mountains as in most of North Carolina is population growth and its associated development. The need for properly installed BMPs and setbacks is even more important in the steep graded mountains to reduce the nutrients and sediments reaching the waters. Fortunately these WS catchments are protected.

# Little Tennessee River Basin

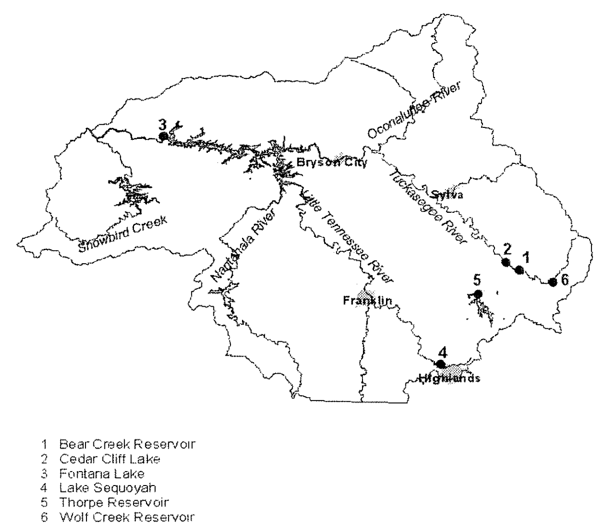
## Basin Overview

The Little Tennessee River basin is located within the Blue Ridge Province of the Appalachian Mountains of western North Carolina. It encompasses about 1,800 square miles in Swain, Macon, Clay, Graham, Cherokee, and Jackson counties. Much of the land within the basin is federally owned (49 percent) and in the U.S. Forest Service's Nantahala National Forest (including the Joyce Kilmer/Slick Rock Wilderness Area) or the Great Smoky Mountains National Park. The basin also includes the Cherokee Indian Reservation.

The North Carolina section of the Little Tennessee River is typical of many other mountain rivers. The gradient is relatively steep in most reaches of the river and the substrate is dominated by riffle habitats. The headwater reaches of the Little Tennessee River are located in Georgia. The water quality of the streams and rivers in the Little Tennessee River Basin is generally high. The basin drains mainly undeveloped mountain areas and contains many white water rivers and trout streams. Sediment carried by nonpoint source runoff is the dominant water quality problem in this basin. Sources of nonpoint impacts to water quality include agriculture, mining operations, silviculture, and urban runoff. Additionally, flow regulation through reservoir releases affects most of the major tributaries in the basin.

Six water supply reservoirs have been sampled in the Little Tennessee River basin: Bear Creek Reservoir, Cedar Cliff Lake, Fontana Lake, Lake Sequoyah, Thorpe Reservoir, and Wolf Creek Reservoir. Of those, only Lake Sequoyah had any exceedances of water quality standards and these are discussed below.

**Water Supply Reservoirs Sampled by DWQ in the Little Tennessee River**




## Lakes with Water Quality Concerns

### Cedar Cliff Lake

Cedar Cliff Lake is immediately below Bear Creek Reservoir on the Tuckasegee River. It is owned by Nantahala Power & Light Company (NP&L), which created the reservoir in 1952. The reservoir's watershed is within the Nantahala National Forest. The watershed and shoreline consists primarily of forests with some scattered residences.

Cedar Cliff Lake was monitored by DWQ in June, July and August of 2004. Nutrient concentrations in this reservoir were lower in 2004 than in previous sampling years possibly due to frequent rain events that increased the water level in the lake and decreased residence time. As a result, chlorophyll *a* concentrations, an indicator of algal productivity, were also low.

Despite frequent rainfall within the watershed in 2004, the clarity of Cedar Cliff remained similar to what has been observed by DWQ staff on previous sampling trips. In August, a Secchi depth of 8.1 meters at the sampling site near the dam was recorded, and was the greatest Secchi depth observed at this lake since 1988.

The biological productivity as indicated by the NCTSI score remained low (oligotrophic) in 2004. These scores were similar to the scores from previous sampling trips.

Two pH values were below the standard during the August 1996 sampling run. These values do not seem to be indicative of pH problems in the lake and may have been related to construction work that was happening in the watershed during sampling. Values for pH since that date have all been above the standard,

### Lake Sequoyah

Lake Sequoyah, an impoundment of the upper Cullasaja River, is located near the Town of Highlands. The lake's shoreline consists of residential homes and commercial businesses. The Highlands Country Club, which consists of a golf course and private homes, is also located in the watershed. However, much of the watershed is undeveloped and lies within the Nantahala National Forest. In addition to being used as a water supply, Lake Sequoyah is also classified as trout water (Tr) based on the classifications of its tributaries. The Town of Highlands withdraws water from the upper end of the Big Creek arm of the lake.

Lake Sequoyah was monitored by DWQ in 2004. This lake was described as appearing muddy on the June 1st sampling trip. Low dissolved oxygen values suggested an increase in oxygen consumption via biological activity spurred by elevated concentrations of total phosphorus. However, chlorophyll-a values were low until November when a concentration of 19 ug/L was recorded, which is above the chlorophyll-a standard for Tr lakes of 15 ug/L. Frequent rainfall events within the lake's watershed during the summer of 2004 may have contributed to the increase in nonpoint source runoff, decreased water clarity and total phosphorus in comparison with levels observed in 1999, which was a drier year.

All of the chlorophyll-a concentrations were greater than 15 ug/L in 1988 at 19, 20, and 23 ug/L during July. Phytoplankton samples reflected mesotrophic to eutrophic lake conditions. Seven algal species found in the samples are known to contribute to taste and odor problems in drinking water.

There have been no complaints of taste or odor problems from processed raw water taken from Big Creek near the point where the creek widens into the arm of Lake Sequoyah[1]. There have also been no recently reported problems with low dissolved oxygen, nuisance aquatic macrophytes, or algal blooms in the lake.

A water quality study of the lake was conducted from early May through late October 1997. The study was commissioned by the Town of Highlands to characterize the existing water quality. The town currently withdraws water from Big Creek, a tributary of Lake Sequoyah. Demand for drinking water exceeds what the creek can deliver, resulting in concerns that more water is being taken from the lake proper than from Big Creek alone. For this reason, the Town of Highlands has a strong interest in having Lake Sequoyah used as a public water supply source. Currently, the lake is designated WS-III because of its location relative to the water intake in Big Creek.

No apparent water quality problems that would preclude the lake's use as a water supply for the town were found during the 1997 study period. No algal blooms were observed; the phytoplankton communities contained few taxa and nuisance algae species were not abundant.

While Lake Sequoyah supported all of its designated uses in 2004, the potential for nonpoint source nutrient and sediment contributions to this small reservoir during

[1] Wade Wilson, Superintendent of the Town of Highlands Water Treatment Facility. Personal communication 2004.

rainfall events may warrant a need to add (or improve existing) best management practices within the watershed. The Town of Highlands has taken measures to address problems related to sedimentation and runoff including adoption of an erosion and sediment control ordinance in 1992 and a watershed buffer plan and ordinance in 1994. The Upper Cullasaja Watershed Association has also successfully initiated a wide range of water resource quantity and quality projects starting in 1999. The Division continues to support efforts by the local governments and citizen-based watershed organizations. More information regarding local efforts in the Little Tennessee River basin is available in the Little Tennessee River Basinwide Planning document[2].

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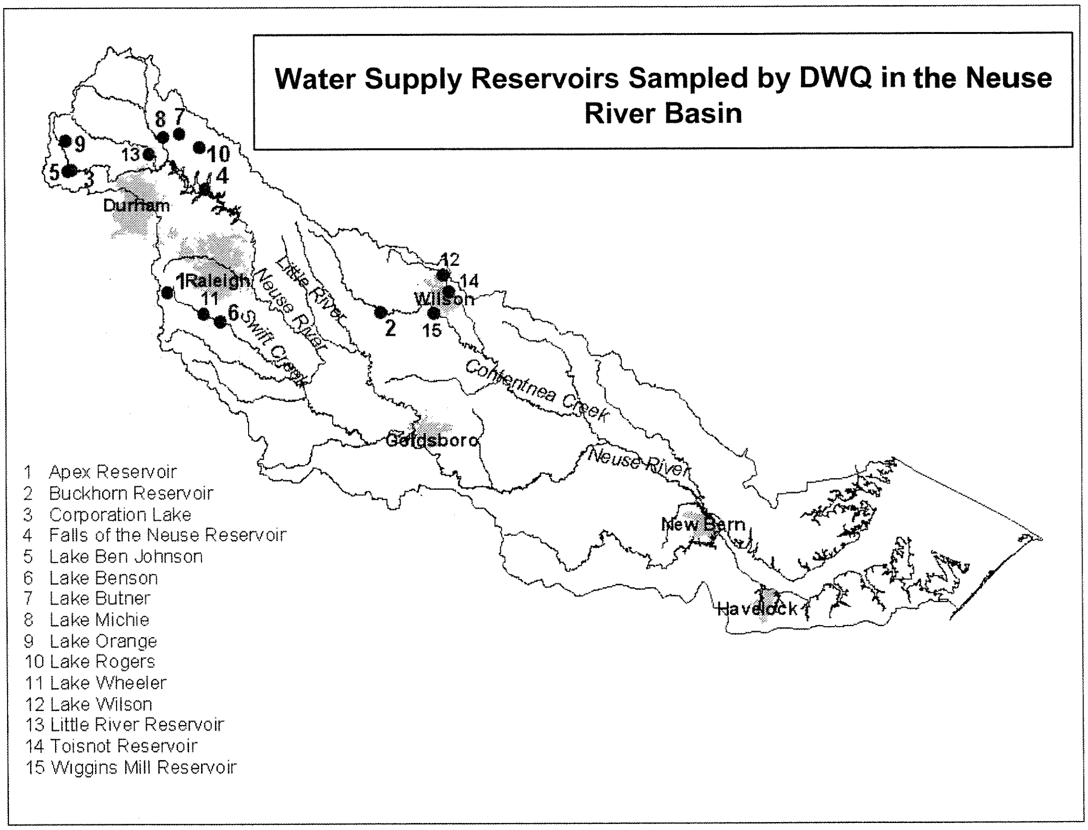
[2] DWQ 2002 Little Tennessee River Basinwide Water Quality Plan. http://h2o.enr.state.nc.us/basinwide/Little_Tennessee/2002/2002_plan.htm

# Neuse River Basin




## Basin Overview

The Neuse River Basin covers 16,000 square kilometers in the lower piedmont and coastal plain of North Carolina. It is the third largest basin in the state. The upper boundary of the basin begins northeast of Durham and drains the region that includes the tributaries of Falls of the Neuse Reservoir. The basin follows the Neuse River down to Kinston and includes the tributaries to the Neuse in this region. Below Kinston, the Neuse River becomes estuarine. The basin continues to the coast and includes portions of Pamlico and Carteret Counties.

In December 1983, the EMC designated the portion of the Neuse River basin upstream of the Falls of the Neuse Reservoir dam as NSW. Severe nutrient enrichment observed in the headwaters of the reservoir appeared to be aggravated by ongoing, rapid urban growth in the watershed. The lower section of the Neuse River basin water was subsequently classified as NSW in January 1988 due to nuisance algal growth, sporadic blooms of undesirable blue-green algae, and fish kills.

There are 15 lakes classified as WS that DWQ samples in the Neuse River Basin. Beaverdam Reservoir is included in the analysis of Falls of the Neuse Reservoir due to their close proximity. Falls of the Neuse Reservoir was the only lake reviewed with more than 10 percent exceedances of the eutrophication-related standards.

Corporation Lake, Lake Ben Johnson, Lake Benson, Lake Wheeler and Toisnot Reservoir did have exceedances of the manganese WS standard with highest concentrations associated with higher turbidities. Toisnot Reservoir will be discussed below due to sedimentation and "brown tap water". Little River Reservoir had two low dissolved oxygen readings in 1997; however, based on all other data these seem to be outliers and not indicative of water quality problems. Corporation Lake had one turbidity sample in 2000 that exceeded the standard. All other water quality samples from Corporation Lake were below the standards.

## Lakes with Water Quality Concerns

### Buckhorn Reservoir

Buckhorn Reservoir is one of four water supply reservoirs used by the City of Wilson for raw water supplies. The reservoir is located on Contentnea Creek just downstream of the confluence of Moccasin and Turkey Creeks. Land use is mostly agricultural. The reservoir was expanded from 750 acres to approximately 2,300 acres in 1999 and was filled to this new capacity by Hurricane Floyd in September 1999.

Sampling has not been conducted on Buckhorn Reservoir since 1995. At that time all surface water quality standards were being met. Prior to 1995, DWQ had conducted a special study of the reservoir during 1991 to assess nutrient enrichment and to determine the relative contribution of nutrients from point and nonpoint sources. That study determined that Buckhorn was responding to enrichment as demonstrated by elevated chlorophyll-a concentrations and high algal density estimates. Nutrient budgets for Buckhorn indicated that agricultural run-off was the largest contributor of nutrients in the watershed.

Contentnea Creek including Buckhorn Reservoir was listed as impaired in 1998 due to degradation of biological integrity and low dissolved oxygen. These impairments were attributed to agricultural inputs. Based on these water quality impacts and the increased development in the watershed, DWQ is working with discharges to minimize their impacts on the creek and reservoir[1].

### Falls of the Neuse Reservoir

Falls of the Neuse Reservoir is a multi-purpose impoundment of the Neuse River located in the Upper Neuse River basin. The reservoir is the primary water supply source for the City of Raleigh and surrounding towns in Wake County. The various uses authorized for the reservoir include: water supply, flood control, recreation, wildlife enhancement, and augmentation of low flows for purposes of pollution abatement and water quality control in the Neuse River basin.

The Falls of the Neuse Reservoir dam was constructed and filled by 1983 and is currently operated by the United States Army Corps of Engineers (USACOE). The reservoir extends 28 miles up the Neuse River to just above the confluence of the Eno and Flat Rivers. At normal pool elevation, the lake has a surface area of 11,310 acres. It drains a watershed area of 494,600 acres or approximately 770 square miles including parts or all of 6 counties (Person, Orange, Franklin, Durham, Wake and Granville). About 12 percent of the watershed is protected open space, 16 percent is in agriculture and 17 percent is urban and suburban development. The entire Triangle area of North Carolina is experiencing tremendous growth and the Falls of the Neuse watershed is experiencing more urbanization.

DWQ has been sampling Falls of the Neuse Reservoir since April 1983 and has continually documented higher upstream nutrient and turbidity concentrations. In 1995, The Cadmus Group, Inc. prepared a report for DWQ on the Falls watershed and reviewed existing data. The report noted problems related to eutrophication and the cumulative impacts from multiple sources.

The Public Utilities Department of the City of Raleigh has been collecting water quality data on the reservoir including algal toxin

[1] DENR. 2002. 2002 Neuse River Basinwide Water Quality Plan. http://h2o.enr.state.nc.us/basinwide/index.htm

measurements. Toxins have been found in the water in amounts below those the World Health Organization considers dangerous for human consumption. North Carolina does not have a standard for algal toxins at this time, nor do most of the other states in the US.

Local governments in the upper Neuse River watershed have come together and developed the Upper Neuse River Basin Association (UNRBA). This group has developed a management plan for the Falls of the Neuse Reservoir watershed and is working together to protect and improve water quality in the upper basin.[2]. There are 8 municipalities, 6 counties, and local Soil and Water Conservation Districts in the Association. They are currently developing an implementation plan to put the recommendations from the management plan into place.

Concerns over potential increases of nitrogen into Knap of Reeds Creek due to increases at the Butner WWTP have resulted in DWQ conducting additional sampling and working with a group of stakeholders to develop monitoring and modeling strategies for the entire lake. This effort began in 2005 and is currently scheduled to continue through December 2006. The same legislative bill (SB981) that required the development of this document is driving the timeline for this work.

### Lake Michie

Lake Michie serves as water supply for the City of Durham. It was built by the city in 1926. The watershed is largely undeveloped with forest covering around 50 percent of the area. Agriculture is the next highest land use (26 percent) and there is some residential development (<4 percent)[3]. Three counties are located in the watershed: Durham, Orange and Person.

One chlorophyll-a concentration exceeded the state standard in 1988. All samples taken since then have been below 11 ug/L. During 2001 and 2005, drought conditions forced the closing of Lake Michie to recreational users and resulted in conservation measures being enacted by the City of Durham.

A recent study prepared for the UNRBA[4], recommends that the Counties and Durham and Roxboro Cities "cooperatively protect critical lands in the watershed and negotiate a set of performance standards, limiting pollutant levels in the watershed." The association is currently developing an implementation plan to put the recommendations from their Upper Neuse Watershed Management Plan to work.

### Lake Rogers

Lake Rogers is located on Ledge Creek in Granville County and serves as the water supply for the City of Creedmoor. It is very shallow due to sedimentation and has been stocked with grass carp to control aquatic weeds, including Hydrilla. The watershed consists of forested areas as well as some residential, agricultural, and wetland areas.

Sampling by DWQ has indicated elevated nutrient concentrations and exceedance of the chlorophyll a, manganese and total dissolved solids standards for WS waters. Leaking septic tanks have been identified as one potential source of the elevated nutrients and plans are being developed by the City to address that source[5]. Agricultural operations, deforestation and erosive soils have contributed to the sedimentation problems.

Due to problems with sedimentation and aquatic weeds, the City as developed a restoration plan for the lake that includes dredging. Funding has been obtained

[2] Their web page is http://www.unrba.org/index.shtml

[3] Upper Neuse River Basin Association. 2003. Upper Neuse Watershed Management Plan.

[4] Archibald, M; D Cummings; J Grimes, E Polk; A Reese; and H Sohn. 2004. Protecting Water Quality in North Carolina's Flat River Watershed: Policy Options and Processes. A report prepared for the Upper Neuse River Basin Association and Jurisdictions in the Upper Neuse River Basin. http://www.unrba.org/

[5] City of Creedmoor – Board of Commissioners. 2005. Minutes of August 23, 2005 Regular Meeting and Public Hearing. www.cityofcreedmoor.org

through the Divison of Water Resources (DWR) and Army Corp of Engineers (ACOE). Restoration is expected to cost around $1.5 million and is scheduled to begin in 2006. The City also has a CWMTF grant to acquire buffers on Lake Rogers and the Environmental Enhancement Program (EEP)has targeted this local watershed for restoration and development of a Local Watershed Plan.

Another step to improve water quality on the lake was taken by the City in 2005 when they banned the use of gas-powered motorboats.

### Toisnot Reservoir

Toisnot Reservoir is a water supply source for the City of Wilson and surrounded by a municipal park. A pedestrian bridge crosses the mid-section of the lake and provides access to both sides of the park. The drainage area is swampy and flat, resulting in tannin-stained water and naturally lower dissolved oxygen and pH. This lake has experienced problems with sedimentation and nutrients due to nonpoint source inputs. Only 10 acres in surface area, the reservoir holds approximately 37 million gallons of water. The reservoir is very shallow and has been dredged in the past by the City of Wilson to control aquatic weeds and sedimentation problems. There have also been problems with brown drinking water probably due to higher inflows of swamp water from Toisnot Swamp.

Field notes from DWQ's last sampling of this reservoir in 2000 documented muddy islands with established grasses in the upper end. This was during a drought so the reservoir was not at normal pool level. Also noted were numerous domestic ducks as well as a large flock of Canada geese (over 30 birds). The primary parameters that were not within standards based on the lake's current classification were dissolved oxygen and manganese. As the reservoir is part of Toisnot Swamp, the lower dissolved oxygen and tannin-stained water is to be expected; however, the current water quality classification does not reflect the influences of the swamp. There are numerous areas in the coastal portion of North Carolina that were not properly classified swamp during the early years of classification. As resources become available DWQ is planning on conducting the sampling necessary to delineate these waters and reclassify them as appropriate.

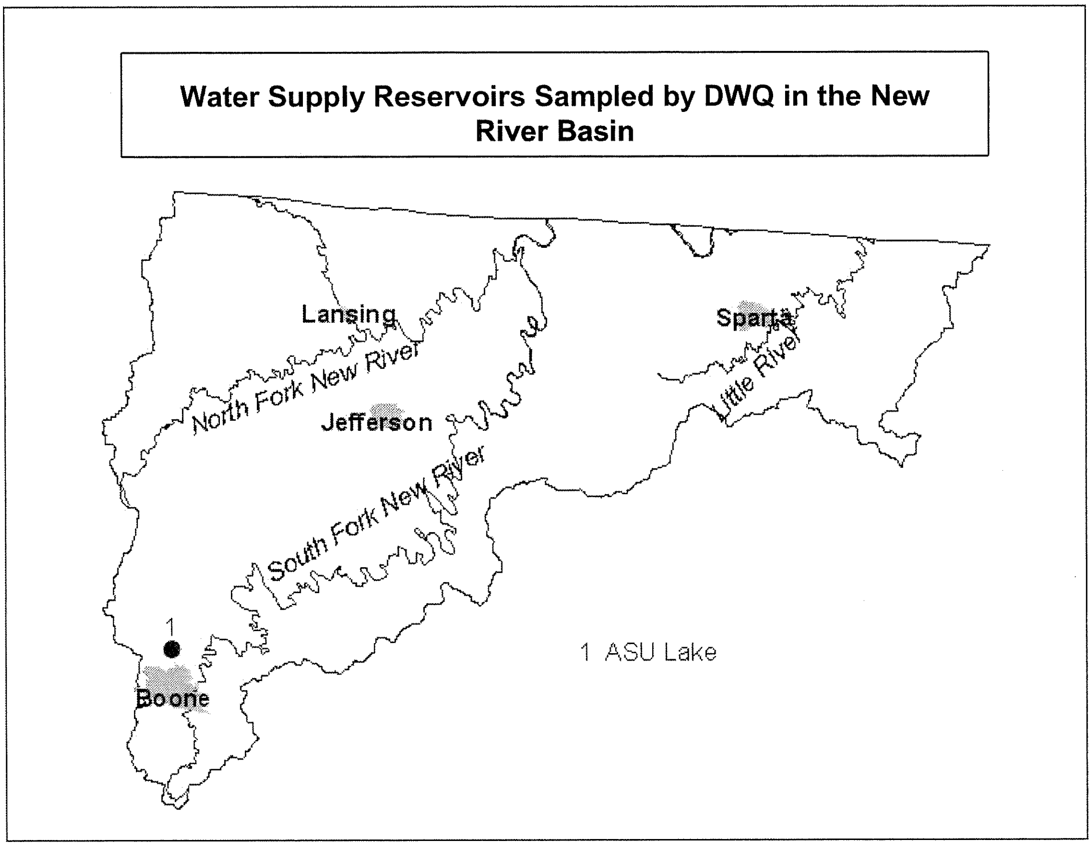
### Wiggins Mill Reservoir

Contentnea Creek was impounded in 1915 to form Wiggins Mill Reservoir. Wiggins Mill Reservoir is located downstream of Buckhorn Reservoir. The City of Wilson owns Wiggins Mills Reservoir and uses it as a water supply and for recreational purposes. Land use in the watershed is dominated by agriculture with some forest, swamp and residential development.

Sampling 1988 and 1991 found exceedances of the chlorophyll-a standard. A review of potential nutrient sources in 1993 found that agricultural run-off was the largest contributor at that time. Water quality since 1991 seems to have improved with no exceedances of any parameters. In 1995, the pH at the mid-lake station was 5.8; however, this is within the calibration limits of the meter and is an outlier when compared to the rest of the data.

Based on the impairment of Contentnea Creek, EEP has named the Contentnea Creek near Wilson watershed (including Wiggins Mill Reservoir) a targeted local watershed as noted in the discussion of Buckhorn Reservoir.

## New River Basin

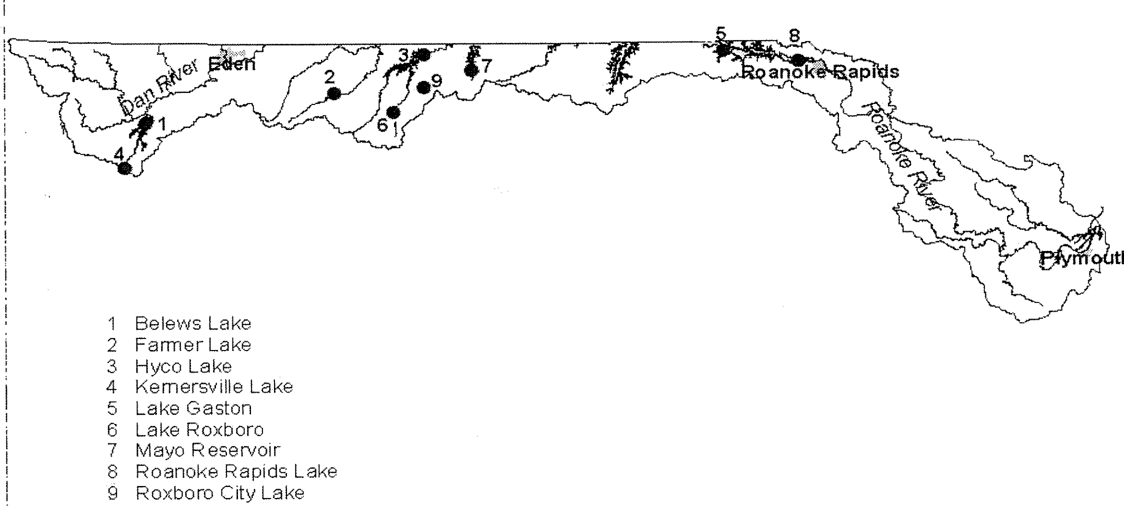



The New River originates at the confluence of the North Fork and South Fork New Rivers in Ashe County, North Carolina. It flows north-northeast into Virginia and West Virginia where it joins with the Gualey River to form the Kanawha River, eventually entering the Gulf of Mexico via the Ohio and Mississippi Rivers. This mountainous basin is located in the Blue Ridge Province of the Appalachian Mountains. Three counties (Alleghany, Ashe and Watauga) are entirely or partially contained with the basin.

Only one WS lake was sampled by DWQ in this basin, ASU Lake. This small water supply impoundment serves as the water supply for Appalachian State University. It is located in the headwaters of Norris Branch and has a maximum depth of 112 feet near the dam. The shoreline is forested; however, the watershed upstream of the lake is a mix of forested land, residential and commercial development. No exceedances of the surface water quality standards have been documented by DWQ in ASU Lake.

## Roanoke River Basin

**Water Supply Reservoirs Sampled by DWQ in the Roanoke River Basin**




### Basin Overview

The Roanoke River basin extends from its source in the Blue Ridge Mountains of Virginia to the Albemarle Sound in North Carolina, encompassing mountainous, piedmont and coastal topography as it flows generally east-southeastward. Its drainage area is 3,503 square miles and includes approximately 2,389 miles of rivers and streams in North Carolina. There are fifteen counties and 42 municipalities in the basin.

The basin is divided into two main areas within North Carolina: the Dan River and Roanoke River drainage areas. The Dan River originates in the western mountains of Virginia and meanders across the North Carolina/Virginia state line several times as it travels eastward. The Roanoke River also flows from Virginia into North Carolina and, together with the Dan River, forms the headwaters of John H. Kerr Reservoir. Kerr Reservoir drains into Lake Gaston, which in turn drains into Roanoke Rapids Lake. From there the Roanoke River travels southeastward to the Albemarle Sound.

Around 60 percent of the land in the basin is forested and 22 percent is in cultivated cropland. Only around six percent of the land falls into the urban/built-up category. Despite the large amount of cultivated cropland and the relatively small amount of urban area, the basin has seen a significant decrease (-105,300 acres) in cultivated cropland and increase (+77,700 acres) in built-up areas between 1984 and 1999[1]. Water quality in the basin has been impacted by hydromodification, agriculture and minor non-municipal discharges.

[1] DENR 2001 Roanoke River Basinwide Water Quality Plan. http://h2o.enr.state.nc.us/basinwide/roanoke/2001/2001_Roanoke_wq_management_plan.htm

Roanoke Rapids Lake is on the 303(d) list for impaired aquatic life due to aquatic weeds (*Hydrilla*, *Egeria*, and *Myriophyllum spicatum*) and a management strategy has been sent to EPA for approval[2].

None of the lakes in the Roanoke River basin exceeded the eutrophication-related standards in more than 10 percent of the samples. Lake Gaston is discussed in more detail as it is on the 303(d) list for impaired aquatic life and for earlier problems related to low dissolved oxygen caused by discharges from John H. Kerr Reservoir. John H. Kerr Reservoir is not classified as WS. Kernersville Lake and Roxboro City Lake met all WS standards except manganese. No reports of taste and odor in the treated drinking water were received by DWQ and concentrations were close to the standard for WS of 200 ug/L.

## Lakes with Water Quality Concerns

### Farmer Lake

Farmer Lake is a 365-acre lake owned by Caswell County and used for water supply, fishing and waterfowl hunting. The City of Yanceyville draws water from Farmer Lake under an agreement with Caswell County. It was built in 1983 and is located on an unnamed tributary of Country Line Creek in Caswell County. This lake has a volume of 1.8 billion gallons with a 48 square mile watershed.

Chlorophyll-a concentrations exceeded the standard once in 2002, turbidity readings have been elevated over the years and manganese was above the standard in samples taken during 2000 through 2005. The 2005 assessment of this lake[3] indicated that additional sampling is warranted to determine if there is a trend in increasing turbidity and nutrients in the lake. This will be undertaken as resources become available.

### Lake Gaston

Lake Gaston is located on the North Carolina-Virginia border just downstream from the John H. Kerr Reservoir dam on the Roanoke River. The lake was built in 1962 by the Virginia Electric and Power Company (now Dominion Power) for hydroelectric power generation. The lake is used extensively for recreation with residential development, campgrounds, golf courses, marinas, and beaches located along the shoreline. Virginia Beach currently gets water from Lake Gaston for drinking water.

In 1996, Lake Gaston was partially supporting designated uses due to an infestation of aquatic plants. The lake was described as having "prolific growths of aquatic macrophytes", especially *Hydrilla*, that hindered activities such as boating and water skiing on a large portion of the lake. Since then, the Lake Gaston Weed Control Council, in cooperation with the NC Division of Water Resources, began controlling the weeds through applications of aquatic herbicides and the introduction of grass carp[4]. These efforts are on-going and the Lake remains on the 303(d) list for impaired aquatic life due to aquatic weeds.

Prior to 2000, sampling indicated dissolved oxygen at and below the instantaneous dissolved oxygen standard of 4 mg/L at the upper end of Lake Gaston. These low concentrations were due to releases of water from deep within Kerr Reservoir (directly upstream of Lake Gaston). In 1999, the first of seven new turbines were modified at the Kerr Dam to increase downstream dissolved oxygen. Improvements were seen in the 2004 sampling.

Lake Gaston has a strong citizens' group in the Lake Gaston Association looking after their and the lake's best interest. This group developed the Lake Gaston Weed Control Council and continues to develop programs to support water quality in the lake. Associations such as these are to be commended.

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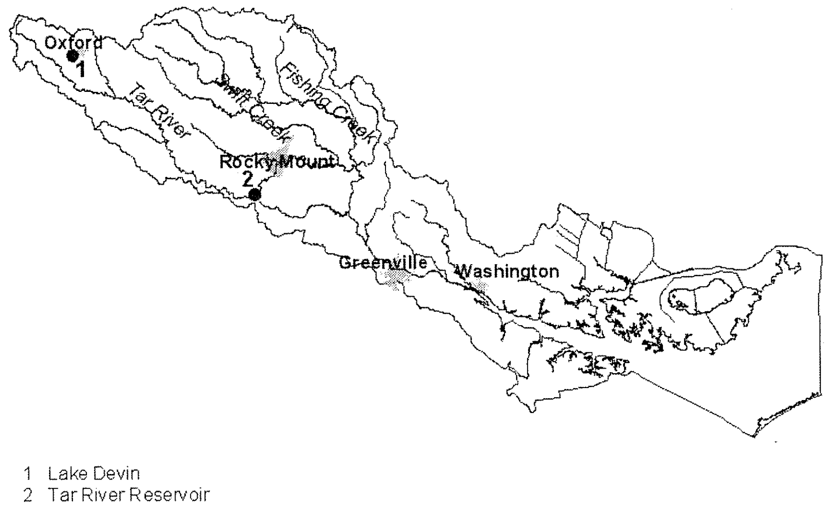
[2] DENR 2005. Lake & Reservoir Assessments – Roanoke River Basin. Environmental Sciences Section. Raleigh, NC.

[3] DENR 2005. _____

[4] For more information on the Lake Gaston Weed Control Council visit http://lgwcc.org/

# Tar-Pamlico River Basin




**Water Supply Reservoirs Sampled by DWQ in the Tar Pamlico River Basin**

## Basin Overview

The Tar-Pamlico River basin encompasses a 5,440 square mile watershed drained by 2,355 miles of streams and with 634,400 acres classified as salt waters. It is the fourth largest river basin in the state and is contained entirely within the state. From its headwaters within the eastern piedmont the Tar River flows 180 miles southeast towards the coastal plain and Pamlico Sound.

The river is called the Tar River from its source in Person County to US 17 in the Town of Washington, a distance of about 140 miles. From Washington to Pamlico Sound it is called the Pamlico River. The Pamlico River is entirely estuarine, while the Tar River is primarily freshwater. Major tributaries include Fishing, Swift and Tranters Creeks, Cokey Swamp, and the Pungo River.

Part or all of 16 counties are found within the basin: Beaufort, Dare, Edgecombe, Franklin, Granville, Halifax, Hyde, Martin, Nash, Pamlico, Person, Pitt, Vance, Warren, Washington, and Wilson. The larger urban areas are Greenville, Henderson, Oxford, Rocky Mount, Tarboro, and Washington. Recent land cover data indicated that most of the basin is in forested and wetland areas, followed by cultivated cropland, open water area, pasture and other managed herbaceous areas, and urban areas.

The entire basin was designated as Nutrient Sensitive Waters (NSW) in 1989 in response to the problems associated with nutrient loading and the resulting eutrophication. Only two lakes are classified as WS were sampled within this basin: Lake Devin and Tar River Reservoir. Both had exceedances of eutrophication-related water quality standards.

## Lakes with Water Quality Concerns

### Lake Devin

Lake Devin, a very small impoundment on Hatchers Run, was the water supply reservoir for the Town of Oxford from 1953 until 1993. The drainage area is mostly forested with some agriculture. There are limited recreational opportunities on the lake.

Chlorophyll-a measurements in 1989 exceeded the state standard; however, no further exceedances were documented in 1997 and 2002. Blue-green algae dominated the phytoplankton community at times in 1997 and 2002. *Lyngbya wollei*, a problematic filamentous blue-green algae in southeastern reservoirs, was found in the lake in 1997 but was not found in the 2002 samples.

In the 2004 Tar-Pamlico River Basinwide Water Quality Plan, DWQ recommended that the water quality in Hatchers Run be protected during land development activities and that BMPs be implemented on all land activities to reduce nutrient inputs.

### Tar River Reservoir

In 1971, the City of Rocky Mount impounded the Tar River to form Tar River Reservoir. In addition to owning the property on which the reservoir lies, the City has a 3 to 5 foot elevation buffer around the shoreline. The volume of the lake is 4.3 billion gallons with a maximum depth of 12 meters. The reservoir is primarily used as a source of drinking water for the Rocky Mount and for public recreation. The only major tributary is Sapony Creek, which forms a large arm near the dam. The reservoir has been sampled eight times by DWQ since 1989.

In 2002, Secchi depths were less than one meter and nutrient concentrations increased from June to August. This increase coincided with a decrease in the lake level as a result of the prolonged statewide drought. By August the water level had decreased another four feet and the water appeared muddy. Chlorophyll-a values ranged from moderate to elevated with the highest concentrations observed in August. Only one concentration (46 ug/L) was greater than the state water quality standard of 40 µg/L. The reservoir was consistently eutrophic in 2002.

The reservoir was previously monitored in 1997. Secchi depths were generally less than one meter. Values for total phosphorus, turbidity, and total solids in 1997 were less than values measured in 2002.

Turbidity exceeded the lake standard of 25 NTU twice during 2002 (17 percent).

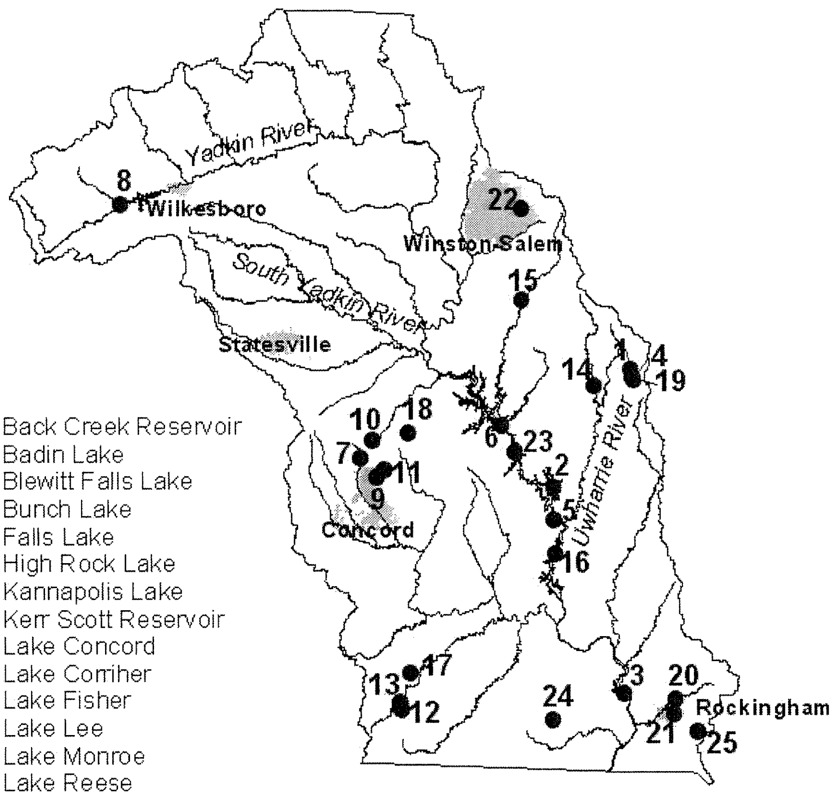
Based on the potential water problems noted above and the fact that the Reservoir is a public water supply, the EEP has identified it as one of 27 local watersheds in the basin with the greatest need and opportunity for stream and wetland restoration efforts. This watershed will be given higher priority than nontarget watersheds for implementation of EEP restoration projects.

Elevated manganese concentrations in the summer have been a major problem for the Water Treatment Plant; however, algal populations have never caused taste or odor problems. In addition to treating for manganese, the City has also had to budget money for treatment of Hydrilla in the Sapony Creek arm of the reservoir[1]. That treatment is scheduled for 2007.

[1] Paul Blount, Director of Water Resources for the City of Rocky Mount. Personal communication, January 19, 2006.

# Yadkin-Pee Dee River Basin

**Water Supply Reservoirs Sampled by DWQ in the Yadkin-Pee Dee River Basin**




1 Back Creek Reservoir
2 Badin Lake
3 Blewitt Falls Lake
4 Bunch Lake
5 Falls Lake
6 High Rock Lake
7 Kannapolis Lake
8 Kerr Scott Reservoir
9 Lake Concord
10 Lake Corriher
11 Lake Fisher
12 Lake Lee
13 Lake Monroe
14 Lake Reese
15 Lake Thom-A-Lex
16 Lake Tillery
17 Lake Twitty (Lake Stewart)
18 Lake Wright
19 McCrary Lake
20 Roberdel Lake
21 Rockingham City Lake
22 Salem Lake
23 Tuckertown Reservoir
24 Wadesboro City Pond
25 Water Lake

## Basin Overview

From its headwaters in northwestern North Carolina and southern Virginia, the Yadkin River flows southeast across North Carolina's densely populated midsection. Three of the state's five interstate highways cross the upper half of the basin. The Yadkin River basin is the second largest basin in North Carolina, covering 7,213 square miles within twenty-one counties. Ninety-three municipalities are located within this river basin. From the eastern slopes of the Blue Ridge Mountains in Caldwell and Wilkes counties, the Yadkin River flows northeasterly for about 100 miles, and then flows to the southeast until it joins the Uwharrie River to form the Pee Dee River. The Pee Dee River continues flowing southeasterly to the North Carolina-South Carolina state line and then through South Carolina to Winyah Bay.

The river is impounded several times as it travels through North Carolina forming the Yadkin Chain Lakes. These reservoirs include W. Kerr Scott Reservoir, High Rock Lake, Tuckertown Reservoir, Badin Lake, Falls Lake, Lake Tillery and Blewett Falls Lake. The Yadkin drainage encompasses much of the Piedmont Triad area including the cities of Winston-Salem, High Point, Thomasville and Lexington. Land use is mixed with forests, agriculture, and urban development.

Twenty-five lakes classified as WS were sampled within the Yadkin-Pee Dee River basin. High Rock Lake exceeded chlorophyll-a, pH, and turbidity standards in more than 10 percent of the samples taken.

## Lakes with Water Quality Concerns

### High Rock Lake

Located on the mainstem of the Yadkin River in Rowan and Davidson counties, High Rock Lake is the largest and most upstream of the Yadkin-Pee Dee chain lakes. Completed in 1929, the reservoir was constructed to provide hydroelectric power and is owned and operated by Yadkin Division of APGI. With a 3,850 square mile watershed, the lake has a volume of approximately 83 billion gallons and a surface area of approximately 15,750 acres. No drinking water is drawn directly from the lake, although Salisbury's water supply intake is located just upstream of the reservoir and the Town of Denton draws water just below the dam. Due to numerous discharges (155 individual NPDES permitted dischargers) and potential sources of contamination in the watershed, High Rock Lake has a Higher Susceptibility Rating under the SWAP. This rating indicates that there are many potential sources of pollution in the watershed that could adversely impact High Rock Lake's water quality.

Eutrophic conditions in High Rock Lake have been documented by DWQ since 1974[1]. In the 1998 basinwide plan, several recommendations were made to address over-enrichment in portions of the lake. Phosphorus limits were recommended and subsequently implemented in the Abbotts Creek arm of the lake in the NPDES permits for Lexington, Thomasville, and High Point WWTPs. The Town of Spencer removed their discharge from Grants Creek, a major tributary of High Rock Lake, and connected to the City of Salisbury's WWTP. The City of Salisbury eliminated its discharges to Grants Creek and Town Creek by constructing a new WWTP that discharges to the Yadkin River in the upper reaches of High Rock Lake.

Water quality data over the past 24 years indicates 44 exceedances (n=156) of the chlorophyll-a standard, 19 of those recorded since June 2002. Values for pH have exceeded the standard 14 times, usually co-occurring with the elevated chlorophyll-a concentrations. Turbidity has been exceeded 23 times with some measurements over 10 times the standard. Most of the turbidity exceedances occurred at the upper stations reflecting the amount of sediment that is coming into High Rock Lake from its upper watershed.

Mild to severe blooms were recorded throughout 2005. The mild blooms recorded in May were dominated by green algae. The

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[1] DENR 2003. Basinwide Assessment Report Yadkin-Pee Dee River. http://www.esb.enr.state.nc.us/Basinwide/

assemblages then shifted to blue greens, which formed moderate to severe blooms in June, July and September. These blooms consisted of multiple filamentous, blue-green taxa, such as *Planktolyngbya* and *Anabaena*. Excessive sediment and detrital matter was frequently noted during the analysis of samples from upper most station. This was the only station that did not have blooms recorded during 2005. It was also noted that the samples at this location contained many benthic diatoms indicating a riparian more than lacustrine system.

In the 2003 basinwide plan, DWQ committed to work more closely with other agencies to assist in reducing nonpoint source pollution to the lake. DWQ also continues to work on relicensing of the hydropower projects in the Yadkin-Pee Dee basin in order to provide greater protection of water quality.

In 2004, High Rock Lake was added to the Impaired Waters list due to turbidity and chlorophyll-a problems. A scoping study was begun in 2005 to support development of a TMDL for High Rock Lake. This study is continuing into 2006 and the final TMDL is scheduled for completion in 2008 or 2009.

### Badin Lake

Badin Lake (also called Narrows Reservoir) is one of the chain lakes on the Yadkin River, located downstream from Tuckertown Reservoir, High Rock Lake and W. Kerr Scott Reservoir. The lake was filled in 1917 and is owned by the Yadkin Division of APGI Hydropower. It has a maximum depth of 53 meters and a surface area of 5,350 acres. The City of Albemarle draws water from Badin Lake. The watershed is forested with some agriculture; however, population growth in the area raises concerns regarding protection and improvement of water quality. DWQ has sampled Badin Lake 18 times since 1981.

Over the past few years, summer fish kills have become a concern. These fish kills are currently under investigation by researchers at NCSU and preliminary results indicate that the stocked striped bass are at the edge of their temperature tolerance zone causing them to be easily stressed[2]. As the lake warms up, the fish look for adequate dissolved oxygen and low water temperatures. At times they get caught in pockets of low dissolved oxygen and higher temperature and die.

A few samples did not meet the standards for chlorophyll a, dissolved oxygen, pH and turbidity. These samples were from throughout the sampling period and did not seem to indicate any decrease in water quality. Mild blooms were recorded in early and mid summer 2002. These blooms were dominated by *Chrysochromulina* sp. (a golden flagellate) and *Psuedoanabaena* (filamentous blue-green). During late summer 2002, moderate algal blooms of *Psuedoanabaena* and *Cylindrospermopsis* (filamentous blue-green) were documented. Similar assemblages were identified in 1987 and 1990.

Relicensing is underway for the hydropower projects on the Yadkin and the Division is working with the Yadkin Division of APGI to provide/ensure water quality improvements through that process[3].

### Lake Lee

Lake Lee was built in 1927 and serves as an emergency water source for the City of Monroe. The lake is fairly shallow with a maximum depth of approximately 10 feet. Water from Lake Monroe feeds into Lake Lee and water from Lake Lee is pumped into a tributary of Lake Twitty during periods of low flow.

Sampling in 1989 found chlorophyll-a concentrations above the standard and then in 2000, two pH readings were above the standard. These readings were accompanied by elevated dissolved oxygen indicating potential algal bloom activity. Surface algal mats and green-colored water were observed at Lake Lee in 2000. An analysis of phytoplankton samples

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[2] Bryn Tracy, Fisheries Biologist DWQ Environmental Sciences Section. Personal communication January 12, 2006.

[3] DENR 2003. Basinwide Assessment Report Yadkin-Pee Dee River. http://www.esb.enr.state.nc.us/Basinwide

confirmed the presence of algal blooms during each sampling event. Samples collected in June were dominated by green algae while samples collected in July and August were dominated by filamentous blue-green algae (*Anabaena* sp. and *Anabaenopsis* sp.) commonly associated with taste and odor problems in drinking water.

As with many other lakes in the basin, manganese concentrations were above the applicable surface water quality standard in one sample. No reports of taste and odor problems were received by DWQ.

### Lake Monroe

Lake Monroe is a secondary (backup) water supply for the City of Monroe in Union County and is also used for recreation. The reservoir was built in 1955 and has a volume of 480 million gallons. The drainage area is mostly forested.

This lake was most recently sampled in 2000. While Lake Monroe was rated eutrophic in 1995, surface dissolved oxygen and pH values were even higher in 2000. Total phosphorus and total organic nitrogen were elevated in both years and the 2000 phytoplankton sample analysis confirmed the presence of algal blooms in June, July and August. Phytoplankton samples from July and August were dominated by filamentous blue-green algae (*Anabaena* sp. and *Anabaenopsis* sp.) commonly implicated in taste and odor problems in drinking water.

### Lake Thom-A-Lex

Lake Thom-A-Lex is a water supply reservoir for the cities of Thomasville and Lexington. Its major tributary is Abbotts Creek.

This lake was monitored in 1999, 2000 and 2001. Sampling was previously conducted in 1994 at which time the lake was determined to be eutrophic. This lake has been consistently eutrophic since it was first monitored in 1981.

Secchi depths in 1999 through 2001 were typical of a piedmont reservoir with readings usually less than one meter. In general, nutrient concentrations were elevated in 1999 through 2001. The availability of nutrients supported increased algae productivity in all years. In 2001, chlorophyll-a values ranged from 24 to 31 µg/L. The exceedances of the chlorophyll-a standard occurred in 1982 and 1989.

As has been seen in other piedmont lakes, the state water quality standard for manganese was exceeded once in the 1999 - 2001 period.

### Salem Lake

Salem Lake is a water supply reservoir providing drinking water for the City of Winston-Salem and Forsyth County. This lake has a maximum depth of 36 feet (11 meters), well-defined north and south arms and 14 miles of shoreline. The watershed includes portions of the Towns of Kernersville and Walkertown. Land use is mainly urban with some agriculture. Sedimentation and agricultural runoff have presented problems in the lake.

Salem Lake has been monitored since 1994, with the most recent samples taken in 2000 and 2001. Overall, the lake is showing some signs of nutrient over-enrichment, based on nutrient concentrations.

Surface dissolved oxygen at Station YAD077B on June 12, 2000 was 3.4 mg/L, which was less than the state water quality standard of 4.0 mg/L for an instantaneous reading. A review of the data indicated that the sample was taken at 9:15 AM and that previous samples taken at the station that early also exhibited low dissolved oxygen compared to the other stations.

In keeping with the moderate to elevated nutrient concentrations found over the years, chlorophyll-a values for 2001 were in the moderate range (12 - 20 µg/L). Phytoplankton samples collected in 1999 indicated that the lake contained a diverse assemblage of algae ranging from blue-green and green algae in the Kerners Mill Creek arm to diatoms near the dam. Exceedances of the chlorophyll-a standard occurred in 1989 due to the presence of a small golden alga, *Chrysochromulina breviturrita*. This alga contains a large amount of chlorophyll-a relative to its size. Chlorophyll-a standards were also exceeded in 1982. No phytoplankton information is available for that time period.

In September 2000, the US Environmental Protection Agency investigated lead contaminated soil at a battery manufacturing plant in Walkertown and at an unnamed tributary to Lowery Creek, which is one of the major tributaries to Salem Lake. Lead levels of 320 µg/L were found in the creek. The NC DWQ's sampling during 2000 and 2001 found lead levels less than the water quality laboratory detection level of 10 µg/L in the lake.

All other parameters were below state standards with the exception of manganese in 2000 at one station in July 2000. Manganese concentrations above the state water quality standard of 200 µg/L for water supply sources are common in the state due to background manganese concentrations.

### Lake Twitty

Lake Twitty (also called Lake Stewart) is owned by the City of Monroe and operated as a water supply reservoir and for recreation. The lake's volume is approximately 2 billion gallons with a maximum depth of 15 meters. Stewart Creek and Chinkapin Creek are the main tributaries to Lake Twitty. Land in the mainly flat drainage area is forested and agriculture.

Lake Twitty was most recently monitored in 2000. The lake was strongly stratified near the dam with hypoxic conditions present at a depth of three meters from the surface (depth to bottom in June was 12 meters). Secchi depths were less than one meter at each of the sampling sites, indicating poor light availability within the water column. Surface dissolved oxygen and pH values were elevated. Elevated dissolved oxygen and pH values are symptoms of increased algal photosynthetic activity in the lake. Field notes indicated that the water was green in color in 2000.

Nutrient concentrations were elevated. Analysis of phytoplankton samples confirmed the presence of algal blooms in June, July and August. Samples collected in June were dominated by green algae while samples collected in July and August were dominated by filamentous blue-green algae. The blue-green algae observed in the July and August samples (*Anabaena* sp., *Oscillatoria* sp., and *Anabaenopsis* sp.) are commonly associated with taste and odor problems in drinking water.

Surface metals were within applicable state water quality standards with the exception of copper. Values in June, July and August (15.0, 9.8, and 76.0 µg/L, respectively) were greater than the state water quality action level of 7.0 µg/L. A conversation with Mr. Allan Kilogh, Water Treatment Plant Supervisor for the Town of Monroe revealed that Lake Stewart was treated with a copper based algaecide twice during the summer. One of these treatment occurred the first week of August. The product used remains in suspension, which explains the elevated copper values. Treatment was done using appropriate application and an algaecide approved for use in water supplies. All precautions were taken to protect the treated drinking water.

In May of 2001, the City of Monroe installed a diffused air hypolimnic system to decrease stratification and increase dissolved oxygen levels throughout the lakes profile to improve the drinking water quality[4].

### Rockingham City Lake

Rockingham City Lake is a secondary water supply reservoir for the City of Rockingham. It is located on Falling Creek.

Rockingham City Lake was most recently monitored in 2000. This lake is dystrophic (tannic water, acidic) with numerous aquatic macrophytes present. Plant samples collected from the lake consisted of spikerush (*Eleocharis* sp.), bog moss (*Mayaca fluviatilis*), variable-leaf watermilfoil (*Myriophyllum heterophyllum*), and fragrant or white water lily (*Nymphaea odorata*).

Due to the naturally dark colored water, Secchi depths were less than a meter. Surface dissolved oxygen concentrations (3.9 mg/L in June and 3.2 mg/L in August) were less than the state water quality standard of 4.0 mg/L for an instantaneous

[4] Russell Colbath, Water Resources Director for the City of Monroe. Personal communication January 18, 2006.

reading. This low dissolved oxygen reading is not considered unusual in the presence of such thick stands of macrophytes. Nutrient concentrations ranged from low to moderate.

This lake has been listed as impaired due to the excessive growth of aquatic macrophytes.